THE CHEST

A Handbook of

ROENTGEN DIAGNOSIS

by

LEO G RIGLER M D
Professor and Chief Department of Radiol gy
University of Minnesota

SECOND EDITION

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Preface to Second Edition

The dynamic character of roentgenology is such that changes in diagnostic methods and criteria occur each year Although there have been no sensational discoveries in the roentgen diagnosis of the chest during the past five years many advances have been made in the details of the methods of roentgen examination and in the diagnostic signs As a result a new edition of this book seemed desirable Considerable new material in a variety of aspects has been added with particular attention to the newer terminology and numerical designation of the bronchi newer technics in bronchography and some new material regarding the early diagnosis of lung tumors

New illustrations have been added and others replaced Because of the difficulties involved in renumbering all of the illustrations in order to accommodate the added pictures and to keep the chronology of the figures intact the new illustrations have been given special numbers by adding a digit to the last old number for example the two new figures following Figure 237 are numbered 237 1 and 237 2

It is my hope that this volume will continue to be a useful introduction to and outline for the study of the roentgen diagnosis of chest diseases Although it does not pretend to be detailed or even complete it may serve as a source for rapid and brief reference for certain chest conditions

My thanks are due Mr William M Holmes for his aid in preparing the new illustrations To my loyal secretary Miss Audrey Derry my gratitude for her invaluable assistance is here acknowledged

—L. G R

Preface to First Edition

The atlas method of presentation seems peculiarly fitting for the elucidation of a field of roentgen diagnosis and it would seem to be especially suitable for the consideration of diseases of the thorax Normal variations and disease processes are more numerous in the chest than in any other part of the body It is clearly impossible from a practical point of view to reproduce more than a portion of the innumerable findings which may appear in roentgenograms of the chest The films presented here were selected to give the most helpful and useful picture of the roentgen diagnosis of chest diseases possible within the space available In many instances to facilitate the presentation of a number of roentgenograms on one page only a portion of some films has been reproduced By this means I have attempted to make available a sufficient body of material to provide a foundation of knowledge and a guide for the analysis of any roentgenogram of the chest No consideration has been given the upper respiratory tract nor have the diaphragms been treated except in relation to the pulmonary findings

For convenience of the reader each case has been designated by a single figure number multiple roentgenograms are indicated alphabetically In general the labeling has been designed to preserve uniform lettering for the same structures in all the figures on any one page

In the interpretation of roentgenograms of the chest as in all phases of radiologic diagnosis the fullest information available regarding the clinical features is necessary if a rational conclusion is to be achieved For the sake of brevity only the most salient facts are given in the discussions of the various figures the apparently categorical conclusions presented are based not on the fluoroscopic or roentgenographic findings alone

but on all the correlated features of the case The figures illus trate the roentgen findings commonly exhibited In almost all of the cases presented the diagnosis has been proved

With few exceptions the cases presented in this volume are from our own files My thanks are due several colleagues who have kindly permitted me to use their roentgenograms as indi cated in the discussion of the films I also wish to acknowledge the courtesy of the editors and publishers who have permitted me to reproduce illustrations I have used previously in the following publications *Radiology*—Figures 36 39 56 57 130 211–214 303 and 305 *International Clinics* (J B Lippincott Company)—Figures 120 129 and 132 *Journal of Thoracic Surgery* (C V Mosby Company)—Figures 297 and 312 *Journal of the American Medical Association*—Figure 310 and *Cyclopedia of Medicine Surgery and Specialties* (F A Davis Company) —Figures 45 47 59 61 62 64 77 301 302 306 and 315

Without the skill and understanding of Miss Jean Hirsch of the University of Minnesota it would have been difficult for me to present the figures as they are now arranged My sincere thanks are extended to her for the arranging labeling and mount ing of the illustrations and for the design of Figure 9 My thanks are also due Mr Henry Morris of the University of Minnesota for his splendid work on the photographic reproductions To the publisher I am indebted for valuable help and advice and infinite patience

—L G R

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The Chest

Introduction

The roentgen examination of the thorax has attained a status of greater utility and more frequent use than has roentgen study of any other portion of the anatomy Developing gradually over the past four decades with variations in technics and methods of examination our knowledge of the interpretation of roentgenograms of the chest has become so complete that examination of the lungs is not considered adequate if it does not include some type of roentgen examination Certainly a negative diagnosis of pulmonary disease cannot be propounded without x ray confirmation Furthermore early lesions of the lung before they are symptom producing are so readily demonstrated by x ray procedures that the routine study of symptomless individuals in mass surveys is rapidly becoming a fixed feature of public health procedures

The pathologic processes which affect the structures of the thoracic cage are multiform their number is legion Practically all of the diseases to which man is heir may in one form or another affect the lungs the bronchi the pleura or the mediastinum Whether a disease is congenital traumatic inflammatory or neoplastic in origin evidence of its effects may be observed within the thoracic cage In addition the etiologic agents of pulmonary diseases are numerous and the individual manifestation vary widely

As a means of disclosing an abnormality within the thoracic structures x ray examination is unsurpassed Lesions as small as 2 mm in diameter are visible particularly if they are favorably situated It is not uncommon to demonstrate a pathologic process long before the patient is conscious of any symptoms The distinction between various types of abnormality presents a far more difficult problem one which is comparable to that of dif

ferentiating various diseases of different origins by the study of the gross pathology alone For example although it is readily possible to demonstrate a cavity within the lung the determination whether such a cavity is tuberculous a nontuberculous abscess a congenital cyst or carcinomatous necrosis may be exceedingly troublesome and at times impossible

In general it may be said that a negative diagnosis of diseases of the lungs cannot be made without x ray examination It is possible without x ray examination to make a positive diagnosis of certain lesions particularly those of the bronchi and occasionally of the lungs themselves but the validity of such a diagnosis is rarely established without confirmation by x ray examination The presence of abnormal processes may be established in their earliest stage by this procedure but the exact determination of the etiology often requires the use of other methods

METHODS OF EXAMINATION

In the study of the thorax an ordered routine of procedures should be followed. Proper roentgen examination of the chest involves the use of many methods; in no other field of roentgen diagnosis is an exacting technic more necessary. Details of roentgen technic in the examination of the chest are treated extensively in various texts. The methods of examination, their indications and special procedures are outlined below.

Roentgen examination, particularly fluoroscopy, involves some risks since x-rays always have deleterious effects. Although the amount of radiation needed for proper radiography of the chest is relatively very small, frequently repeated examinations over a short period should arouse apprehension as to the limits of radiation exposure which are desirable. In fluoroscopy, especially in children, such limits should be sharply observed and the amount of exposure kept to the smallest possible quantity. Adequate discussion of such matters is available elsewhere and the details of the dangers of fluoroscopy and radiography, methods of protection and limitations are too extensive to be considered here. But attention is directed to the fact that there may be some deleterious effects from radiation even in the small quantities needed for examination of the chest.

A. Fluoroscopy

1. Indications

Ideally, every patient presenting himself to a physician, regardless of his complaint, should have a fluoroscopic examination of the chest since it is relatively inexpensive, consumes little time and provides rewards far greater than those obtained from routine physical examination. It is likely that in the future this procedure will become an established routine. Fluoroscopic examination of the chest supplements the routine physical examination and gives information unobtainable in any other way. In large series of cases studied in outpatient departments the value of routine fluoroscopy

of the chest in the discovery of abnormalities is well established

Fluoroscopy should also be done in patients with specific complaints referable to the chest since it permits a valuable survey a kind of scouting expedition In some respects fluoroscopy has advantages over radiography in that the patient may be examined in all the various phases of respiration before and after cough and in a great variety of positions

2 Limitations

The character of fluoroscopic images is such that fine detail can rarely be seen Most probably this is a result of the low illumination afforded by the limited amounts of radiation which are possible With the introduction of methods of intensifying the fluoroscopic light without increasing the amount of radiation some of these handicaps may be overcome Nevertheless fluoroscopy cannot be relied on for the exclusion of small lesions Thus a negative result of fluoroscopic study does not exclude pulmonary tuberculosis of minimal and even in some cases of moderately advanced degree Negative fluoroscopic findings do not exclude moderate degrees of silicosis nor of diffuse fibrotic lesions Small tumors minimal pneumonic consolidations minimal pneumothorax and other lesions of small size are likewise not always visible on the fluoroscopic screen In the consideration of the value of fluoroscopy it should be borne in mind that its usefulness is largely related to the grosser lesions of the thorax

3 Technic

a) The eyes must be thoroughly dark adapted
b) Use of a maximum of approximately 4 ma of current at a maximum of 100 kv peak is desirable Lower milliamperages may be used in children and a lower voltage in adults but the higher voltage is preferable
c) General procedures
Deep inspiration gives the most brilliant view of the lungs But examination in expiration should not be neglected An additional procedure of value is to have the patient

cough or preferably sniff The latter two maneuvers produce sudden increases in intra alveolar pressure with consequent increased illumination if normal or failure to illuminate if abnormal Pendulum motion of the mediastinum resulting from obstruction of a bronchus is best demonstrated by the sniff procedure

(1) An over all view of the whole chest is obtained in inspiration and expiration with the patient facing the examiner

(2) Each diaphragm is examined in deep inspiration with moderate oblique rotation to view the costophrenic angle

(3) In deep inspiration with small diaphragm openings the lungs are viewed in segments from apex to base

(4) The mediastinum is studied especially regarding the position of the trachea heart and hilus shadows of the lungs

(5) The patient is rotated to determine whether the densities in the hilus are vascular or calcified glands

(6) The blood vessels throughout both lungs and at the roots of the lungs are observed for abnormalities of size and pulsation

(7) The patient is rotated to the left anterior oblique position and the mediastinum and heart are examined both in inspiration and in expiration

(8) The patient is rotated to the right anterior oblique position and the mediastinum and heart are examined again in inspiration and expiration

(9) The patient is reversed to the anteroposterior position the arms are rotated so that the scapulae are eliminated from the field and each apex is examined with a small diaphragm opening both before and after cough

(10) Each lung is then examined from apex to base in the anteroposterior view with a small diaphragm opening in deep inspiration

(11) Both lungs are examined simultaneously in deep expiration to determine differences in aeration

(12) A straight right lateral view is then used to observe the position of the heart and aorta and the interlobar fissures

(13) When atelectasis of the middle or lower lobes or interlobar fissure encapsulations are suspected examination in the position of lordosis is undertaken In this position the patient stands facing the examiner with the abdomen pushed far forward and with the shoulders back against the fluoroscopic table

B Roentgenography

The technic of roentgenography of the chest and the apparatus required deserve an elaborate discussion it is well covered in various texts on roentgenographic technic Only certain salient points need be emphasized here

1 Single 14 × 17 in roentgenogram

a) Indications

For most purposes a single film of the chest is sufficient especially if supplemented by fluoroscopy

b) Technic

(1) A tube with an effective focal spot under 2 5 mm should be used but even smaller sizes are valuable

(2) A timer accurate to 1/20 second is important An electronic timer is preferable though not essential Whenever possible the exposure time should not be longer than 1/10 second in order to reduce the effects of cardiac and vascular pulsation

(3) A film focus distance of not less than 72 in should be employed to minimize distortion

(4) The x ray transformer should have a capacity of at least 100 ma to permit rapid exposures at the indicated distance

(5) The peak kilovoltage should rarely go below 60 kv or above 100 kv Increases in time or milliamperage

must be made to compensate if the patient is too thick or too thin to come within the indicated limits

(6) The amount of exposure is determined by measuring the thickness of the patient but with due consideration of the general build as well

(7) Intensifying screens must be flawless Dirt defects or wear may produce shadows simulating abnormalities or obscuring pathologic areas

(8) Good contact between screens and cassettes is essential to eliminate vague areas of blurring which often simulate exudative processes

(9) The patient must be held absolutely motionless fast time must be used to eliminate as far as possible the motion of the intrathoracic structures from vascular pulsation and breathing

(10) Artefacts from articles in the clothing and from braids tumors and other structures on the skin must be taken into consideration in the interpretation of films and should be eliminated as far as possible

(11) The time of exposure must be controlled For this purpose it is valuable to use a spinning top which is constantly on the cassette changer to determine time of exposure accurately Also of some value is an aluminum wedge ladder to give some idea of the degree of penetration used The use of a Morgan Hodges phototimer makes such devices unnecessary and should make it possible to obtain uniform exposures regardless of the thickness of the patient

(12) Routine films should be made at the end of a deep inspiration The patient must be absolutely motionless and holding his breath

(13) Roentgenograms made in deep expiration have particular value in cases suspected of bronchial obstruction

(14) It would be valuable to determine accurately the intra alveolar pressure during the exposure to permit exact duplication on re-examination This can be done

by the use of a water manometer connected with the patient's mouth by a rubber tube as suggested by Westermark. Its routine use is not feasible

(15) Postero anterior views are the best to be used for routine exposures

2 Stereoscopic 14 × 17 in roentgenogram

a) Indications

When minimal lesions are suspected or the single roentgenogram shows suspicious shadows which are not entirely diagnostic stereoscopic films should be made. The technic is the same as that already described except that a rapid vibrationless plate changer is needed to make stereoscopic films possible

It should be pointed out that in the diagnosis of minimal lesions particularly those of early tuberculosis stereoscopic films are highly advantageous both in the detection of early abnormal changes and in the determination of the normal character of various shadows particularly those resulting from interlacing of blood vessels

3 Straight lateral right and left anterior and posterior oblique anteroposterior postero anterior and anteroposterior lordosis and lateral decubitus positions

a) Indications

The findings on fluoroscopic examination and on the single postero-anterior roentgenogram determine what other positions should be utilized for x ray examination These help to localize a lesion bring it out more vividly and determine its borders and its relation to other structures Special positions are of particular value in the delineation of tumors pleural lesions and the exact location of consolidations and their distribution that is in the better delineation of gross lesions The position of lordosis has special value in the demonstration of interlobar effusion atelectasis of the middle lobe on the right and mediastino interlobar involvement The anteroposterior lordosis position of the apexes is used particularly to bring out small tuberculous lesions hidden by the ribs and clavicles

Postero anterior or anteroposterior views with the patient lying on his side the lateral decubitus position are used to disclose small pleural effusions early pneumothorax and changes in fluid levels Roentgenograms with the patient supine or prone are also of value especially in the demonstration of fluid in the pleural cavity

Technic

Increase of routine exposure is necessary to compensate for increased thickness which results when any of these positions are used This may be obtained by using higher milliamperage and shorter distance longer time and to a lesser extent by increasing the kilovoltage in proportion to the thickness of the patient

tter Bucky diaphragm

many instances the Potter Bucky diaphragm is of great lue in the examination of the chest especially when extene pathologic processes increase the density of the thoracic uctures far beyond the normal

Indications

Chronic lung fibrosis massive lung tumors complete atelectasis massive pleural effusions and the postoperative chest—all are indications for efforts to penetrate a dense structure and when this is necessary the Potter Bucky diaphragm may be used In this way the major bronchi may also be observed because of their air content

Technic

Exposure far beyond the normal is used when films are made with the moving diaphragm A fast diaphragm permitting 1/10 second exposure is useful for films made with the patient upright The usual procedures are used but interposition of the diaphragm of itself necessitates a great increase in the total amount of exposure an additional increase is needed because of the overexposure used in such instances The wafer or stationary grid diaphragm may be used for the same purpose Films may be made with the patient supine with heavy penetration through the heart or diaphragms to disclose lesions in these areas

In some cases it is helpful to place a filtering metal plate over the normal side during the first half of an exposure and to remove it during the second half so that double the amount of x rays is applied to the abnormal dense side In this way a good exposure of a very dense hemithorax may be obtained along with a reasonably good exposure of the more normal side

5 Bedside chest radiography

In many patients with acute illnesses such as pneumonia pulmonary edema and acute abscess and after surgery it is desirable to make films of the chest at the bedside These are commonly done with the patient supine although the upright position may also be used The technical factors depend on the capacity of the bedside unit and the outside current which supplies it A great deal of information may be obtained in this manner without seriously disturbing a critically ill patient Generally speaking the films are made at a short film focus distance with increased exposure The lesions to be determined by bedside radiography are usually gross and thus can be clearly delineated despite the distortion which is inevitable with short distances and heavy exposures

Frequently gross lesions such as pneumonia and particularly those occurring in portions of the lungs behind the heart are better exhibited by this means than in the ordinary upright films with moderate exposure The increased penetration produces films of great contrast so that gross lesions are more clearly visible than the normal lung around them The penetration through the cardiac density permits increased delineation of the density produced by lesions in the overlying lungs or pleura

6 Body section roentgenography

a) Indications

To delineate structures within the thorax which are normally obscured by overlying anatomic parts the method usually termed body section roentgenography but often called <u>tomography</u> <u>planigraphy</u> and <u>laminagraphy</u>, is utilized In this procedure during a somewhat prolonged

exposure the x ray film and tube are in motion in opposite directions As a result there is a blurring out of the structures in the path of the x rays However at a point where the x ray beams cross there is a plane which is not blurred but is in fairly sharp focus Such sharpness of detail may be obtained in any plane of the body by a simple adjustment of the relationship between the tube and that portion of the body As a result it is possible to demonstrate fairly sharply a small layer of tissue within the thorax while all of the structures lying anterior and posterior to that layer are fairly well blurred out

Specific indications

To demonstrate the major bronchial tree cavities in the lung deep seated tumors calcifications in the roots of the lungs lesions in and behind the heart mediastinum and diaphragm and lesions covered by the ribs clavicles or other bony structures of the thorax body section roentgenography is utilized It is particularly valuable in the study of tuberculosis tumors of the bronchi nodular lesions in the lung to determine the presence of calcium or cavitation bronchiectasis and bronchostenosis but it may be applied to almost any type of pathologic process in the lungs The procedure requires some co operation from the patient and so is not readily applicable when the patient is acutely ill

Technic

This is not difficult to master but is too elaborate for detailed description in this volume It should be pointed out however that a number of films must be made in each case at varying depths from the anterior or posterior surfaces of the body in order to determine the exact plane in which the process is present In the procedure small films may be used since preliminary examination by conventional methods can be used to localize the portion of the thorax to be investigated

Sectional films in the lateral position are also of great value The combination of anteroposterior and lateral

planigrams at different levels may permit accurate localization of the segment of the lung involved by tuberculosis or other pathologic process and the condition of the bronchus supplying that segment Such information is of great value in carrying out surgical treatment of tuberculosis

7 Bronchography

Study of the tracheobronchial tree by introducing a contrast medium is particularly important in the roentgen examination of chronic lesions involving the bronchi

a) Indications

Bronchiectasis tumors of the bronchi cysts of the lung bronchostenosis pulmonary cavities of any type and bronchial fistulas are all indications for bronchographic examinations

For purposes of orientation in the surgical treatment of various *pulmonary conditions most especially* bronchiectasis "lung mapping" by means of bronchography is very important By this procedure executed at one or more sittings all of the bronchi can be demonstrated so that the segments of the lung which must be removed will be clearly isolated In the same manner the delineation of the segments of the lung affected by an abscess which must be drained can be exactly localized

b) Contraindications

All contrast mediums are bronchial irritants Furthermore they may in rare cases produce chronic lung changes such as *granulomas Therefore body* section roentgenography is preferable to bronchography and should be used whenever possible before the introduction of any contrast substance in the hope of avoiding the use of opaque mediums entirely It is unwise to use iodized oil or other contrast medium immediately before thoracic surgery in acute conditions in patients with marked reduction of vital capacity or when there is any suspicion of iodine sensitivity

c. Contrast mediums

(1) Iodized oil a halogenated vegetable oil containing about 40 per cent iodine

(2) Water soluble organic iodine compounds held in a methyl cellulose mixture They are less opaque than iodized oil somewhat more irritating to the bronchi thus requiring more adequate anesthesia and penetrate into the alveoli more readily The advantages are that they pass more easily into the smaller bronchi and the shadows of the contrast in the alveoli disappear rapidly In the case of iodized oil they may remain for months thus obscuring the roentgen findings

d) Technic of introduction of contrast medium

(1) Passive method

The patient is prepared by sedation with suitable dosage of a barbiturate If there is excessive bronchial secretion drainage by some method should first be instituted The pharynx and larynx are anesthetized by spraying 10 per cent cocaine into the back of the mouth When the pharyngeal reflex has been completely abolished the tongue is drawn out and held by the hand A curved cannula is inserted along the back of the tongue and the iodized oil thoroughly warmed is dripped slowly down the back of the tongue The patient pants during the process and in most instances the material is aspirated through the larynx into the tracheobronchial tree

The procedure is carried out under fluoroscopic control and the patient is then tilted in various directions to insure passage of the material into the particular portion of the tracheobronchial tree to be examined Generally speaking it is advisable to try to examine only two lobes at one sitting only in occasional cases may an entire lung on one side be examined To fill the right lower lobe bronchus the patient is put upright and tilted backward and some

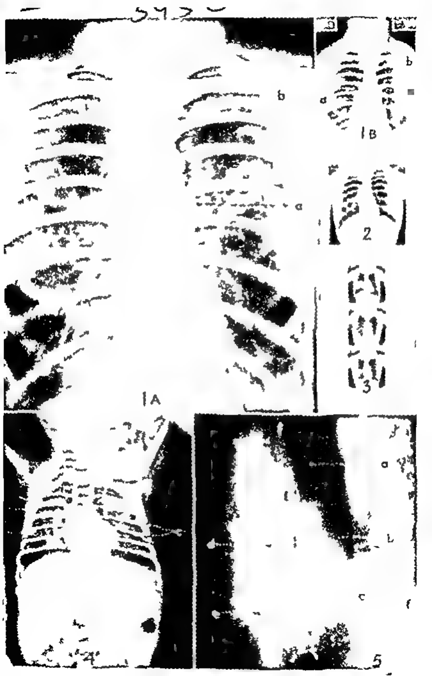
what to the right To fill the middle lobe bronchus he is tilted forward and to the right The middle lobe bronchus may also be filled by having the patient prone and tilted somewhat to the right The right upper lobe bronchus is filled with the patient prone, with the head slightly lower than the feet but sharply tilted to the right To fill the posterior branches of the right upper lobe the patient must be reversed into the supine position with the head somewhat lower than the feet and tilted to the right The filling of the left lobes is accomplished somewhat as are the right lobes except that the tilt is to the left

(2) Catheter method
A catheter may be introduced into the larynx and trachea through the bronchoscope at the time of bronchoscopy Or under local anesthesia it may be passed into the larynx through the nasal orifice by means of a laryngoscope or under fluoroscopic control When the catheter is in place anesthesia of the mucous membrane is induced by injection directly through it The contrast medium is injected through the catheter by means of a syringe and guided into the desired bronchus as already described

(3) Transcricothyroid method
A needle is inserted directly into the trachea after the skin and subcutaneous tissues overlying it are anesthetized The iodized oil is then injected directly into the trachea and the patient tilted in the proper fashion to guide the material into the bronchus This procedure is rarely used now

After the examination is completed the patient is put in the position of drainage to expel as much of the material as possible

It is important that cough be suppressed during the entire examination so that the alveoli are not filled with the contrast medium The oil should not be so thinned by heating that it will tend to extend into the alveoli Despite all


1A
1B
2
3
4
5

owing to the heavy exposure Note the absence of rib shadows wiped out in a film made in this plane

Fig 5—Methods used to determine if an annular shadow in the region of the left first rib was a lung cavity

Fig 6A—Conventional postero anterior roentgenogram *a* irregular area of lesser density resembling an apical cavity *b* infiltration from this area to root of lung probably tuberculous *c* trachea poorly delineated

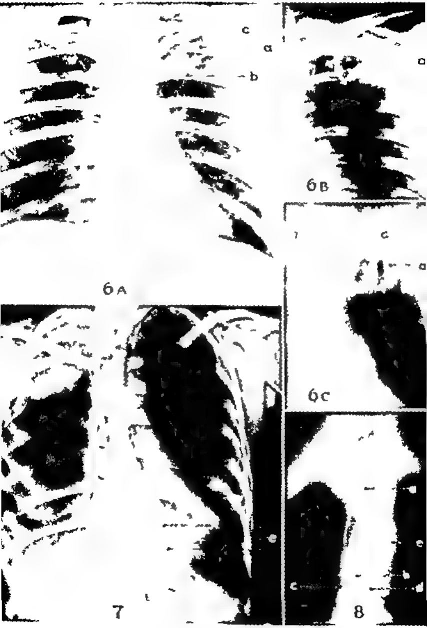
Fig 6B—Roentgenogram of local area with Potter Bucky diaphragm and heavy exposure *a* area is identical with anterior end of first rib Note sclerosis and irregularity of surrounding bone Lung details are lost owing to heavy exposure

Fig 6C—Planigram of local area Anterior end of the first rib is brought out sharply and the defect (*a*) is seen to be a congenital anomaly Trachea (*c*) is well demonstrated but lung detail is lost

Fig 7—Advantage of heavy exposure with the Potter Bucky diaphragm when extensive changes produce dense shadows Densities below the domes of the diaphragms and behind the heart seen poorly in ordinary roentgenograms are sharply outlined Lung fields as a whole are poorly demonstrated because of overexposure *a* oleothorax presenting sharply outlined dense homogeneous mass *b* edge of greatly thickened pleura protruding into lung field *c* thickened pleura *d* fibrosis and bronchiectasis in compressed portion of lung *e* bronchiectasis and fibrosis behind the heart in an area difficult to demonstrate in the ordinary film

Fig 8—Body section roentgenogram planigraphic method Only a small section of the neck and thorax is shown Marked overexposure was deliberate to bring out tracheobronchial tree Note absence of rib shadows blurred out in this plane *a* trachea *b* carina *c* right main bronchus *d* left main bronchus *e* arch of aorta

Compare the trachea and bronchi in Figure 8 with those in Figure 26 (p 59) in which iodized oil was instilled for contrast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8

Normal Observations

THE NORMAL CHEST Adequate interpretation of roentgenograms of the chest requires a thorough knowledge of the normal anatomy of the thorax and the manifestations of that anatomy in the roentgenogram Since anatomic structures vary somewhat from one individual to another and the distinction between the normal and the pathologic is not always sharp it is necessary to set up some standards by which the normal and its variations may be delimited The first step in learning to interpret roentgenograms of the chest consists in a study of normal intra thoracic structures

As is true of all portions of the anatomy all of the contents of the thorax in the path of the x ray beam participate in the shadows produced on the roentgenogram The chest wall itself therefore is important in the composition of the x ray densities of the lungs and mediastinum

Chest wall—The superior inlet of the thorax is bounded by the spine in the midline and by the first ribs circling from their higher posterior attachments to the spine to their more inferior anterior attachments to the sternum The clavicles extend later ally from their attachment to the sternum crossing the first ribs The sternum is not clearly seen in the ordinary postero anterior projection although the outer margins of the manubrium may be apparent The anterior ends of the first rib are cartilaginous in the child and young adult, thus presenting an apparent defect they usually become ossified during the third decade and then present a rather irregular appearance The rest of the sternum is merged with the median shadow of the thorax All the ribs have a somewhat similar character being rather high above and curving laterally from their attachment to the spine and inferiorly through the axilla then anteriorly and still more inferiorly to their junction with the sternum Below the first rib there is

commonly a wide gap between the anterior end of the bony rib and the sternum the costal cartilage occupies this space and normally throws a very faint shadow With age and in certain other conditions some calcification of the cartilages may occur thus producing a very irregular dense, stippled shadow The inferior ribs join to form the costal arch well below the domes of the diaphragms Commonly superimposed on the shadow of the thorax are the scapulae with their triangular shape the wide thick spine above and the narrow angle below In a well made roentgenogram the shoulders are rotated so that the scapulae are not superimposed to any great extent on the shadow of the thorax. Most of the thoracic spine is lost in the median shadow and unless the film is overexposed the individual vertebral bodies cannot be seen Obviously in scoliosis the spine may project to the right or left carrying its shadow outside that of the medi *astinum and thereby becoming visible*

Developmental anomalies of the ribs are extremely common and must not be mistaken for pathologic processes These anomalies include bifid anterior ends fusion between ribs, either anteriorly or posteriorly and spurs In extreme cases there may be complete absence of one or more ribs. Cervical ribs pro jecting down over the apex of the lung from the seventh cervical vertebra are not rare Numerous other congenital anomalies of the bony thorax may occur

The soft tissues of the chest wall both anterior and to a lesser degree posterior portions may make extensive shadows which *overlap those of the thoracic contents The most important of* these are the female breasts they present rounded dense shadows varying somewhat in position depending on how pendulous they are In some instances the shadows of the breasts extend well below the domes of the diaphragms whereas in others especially in young girls they lie at a high level The shadow of the breast causes a rather marked increase in density in the area of lung which it covers beyond the edge of the breast in properly ex posed films the lung field may by contrast appear much more radiable The shadows of the nipples are often seen, the degree of density depending to some extent on their thickness They pre sent a nodular density on either side varying somewhat in posi

tion and should not be mistaken for intrapulmonary lesions The shadow of a breast shrunken by carcinoma or swollen by milk during pregnancy or from inflammation may produce an extensive density simulating an intrapulmonary lesion

In the male, especially in the manual laborer the pectoral muscles produce a conspicuous shadow coursing inferiorly and medially in an oblique fashion across the chest wall They are often developed asymmetrically and thus may produce a difference in density on the two sides

The shadows of the sternocleidomastoid muscles may be quite prominent extending down from the neck over the apex and leaving an area lateral to them uncovered and therefore much more radiable They merge into a linear transverse shadow which overlies the clavicle and represents the projection shadow of the skin in the supraclavicular fossa Absence of this shadow may indicate a supraclavicular soft tissue mass [1] mint shadows may be seen along the course of the first and second ribs over the apexes on both sides often called the accompanying shadows of the first and second ribs they are due to a reflection of the pleura plus soft tissue shadows [1]

In the emaciated or old individual the shadows of folds of skin especially on the posterior chest wall may be striking Similarly in young infants such folds of skin may produce a contrast in densities which simulates pneumothorax

Tumors of the chest wall nodules in the skin such as occur with neurofibromatosis large warts or moles and foreign bodies in the chest wall cause shadows superimposed on the lung fields that are often indistinguishable in the ordinary single roentgenogram from intrathoracic lesions Braids of hair, if permitted to cover the apexes during the exposure may simulate an abnormality such as tuberculosis

Stereoscopic films lateral views and inspection of the thoracic wall may be used to eliminate sources of error

Intrathoracic structures—The thoracic cavity is occupied by a number of structures whose densities fortunately present a striking contrast with each other and thus permit excellent delineation in the roentgenogram The two dome shaped diaphragms delimit the thorax inferiorly It should be noted that

the superior surface of the diaphragm does not delineate the margin of the lung which extends below the dome for a considerable distance both anteriorly and posteriorly In the center is the dense central shadow of the thorax consisting of the mediastinum heart large vessels roots of the lungs trachea and larger bronchi On the two sides are the air filled lungs whose shadows are the result of a combination of vascular lymphatic bronchial and endothelial structures interspersed with air

Both the histologic and the gross anatomy of the lung must be borne in mind if the x ray shadows are to be properly understood On each side is the hilus shadow of the lung the left slightly higher than the right This shadow is produced chiefly by the pulmonary artery but entering into it are the pulmonary veins larger bronchi and hilar or peribronchial lymph nodes It should be noted that the two root shadows are roughly equal in size and density Any marked variation in the relative size of the hili of the two lungs may be of great significance From this root a series of linear shadows extends in all directions toward the periphery of the lung fields They become narrower as they approach the outer margins of the lungs whether lateral medial anterior or posterior These shadows are produced primarily by the pulmonary arteries although entering into the density are the pulmonary veins the tissues of the walls of the bronchi and the lymphatics In the right lower portion of the lung on the medial side, such shadows are exceptionally prominent representing several large pulmonary veins They are also quite prominent along the medial margin of the lung near the vertebrae extending up toward the apex In some areas the pulmonary vessels may be seen on end in an ordinary postero anterior view presenting a round homogeneous, rather dense appearance owing to the long column of blood seen in this view The bronchi also may be seen on end but they have a clearer center and a dense periphery owing to their air content The bronchovascular shadows become extremely thin as the outer margins of the lungs are approached an estimation of their normal thickness is important in arriving at a diagnosis of abnormality in the thorax

Interspersed in the shadows of the vessels are the alveoli of

the lungs filled with air and presenting a generalized homogeneous radiable appearance with a faint uniform pattern The degree of radiability varies directly with the amount of air in the lungs as compared with the amount of blood in the vessels In expiration when the lungs are relatively airless and there is relatively a larger quantity of blood the lungs seem much denser particularly in the lower portion In deep inspiration the lungs may appear much more radiable The blood vessels appear far apart during *inspiration* and *much closer together during expiration* as a result of the change in the space separating them owing to the changes in the air content

Although it is often impossible to distinguish the normal bronchi beyond their major portions in the roots of the lungs some evidence of their presence can be elicited because they accompany the linear shadows of the blood vessels The fine stripelike shadows of lesser density along the vessel markings no doubt represent longitudinal projections of the bronchi The lymphatics however are not clearly contrasted with the surrounding tissues nor is it possible to distinguish the pulmonary veins from the pulmonary arteries

Overlying the lung is the pleura which is so thin normally that it is indistinguishable from the parenchyma of the lung except at certain points Wherever the pleura reflects in such a fashion that large portions are struck tangentially by the x rays a shadow may be visible This is best illustrated in the delineation of the horizontal (minor) interlobar fissure between the middle and the upper lobe Its direction is fairly straight anteroposteriorly so that when a postero anterior roentgenogram of the thorax is made the x rays strike the pleural reflection tangentially and it is recorded as a fine hairline across the thorax The normal oblique (major) fissure is rarely seen because its course is so oblique that only small segments of it are struck tangentially *The mediastinal pleura is occasionally seen particularly* in antero posterior views with heavy exposure as a dense line parallel to the spine on each side

In films made with heavy exposure the inferior margins of the lungs can be made out through the shadow of the diaphragm and the blood vessels of the lungs can be seen coursing down to

the reflection of the pleura When the pleura is slightly thickened its shadow becomes much more apparent especially well out at the periphery

For purposes of orientation the lungs may be divided into a number of segments The apex of the lungs is that which is seen above the clavicle within the limits of the anterior portion of the first rib. The subclavicular area a very important area is that directly below the clavicle usually included within the second and third anterior interspaces The remainder of the lungs may well be considered on the basis of the lobar distribution described below The lungs are also often divided from lateral to medial into an outer middle and inner zone the last including the hilus or root shadow The lower half of the lungs is often called the basal portion

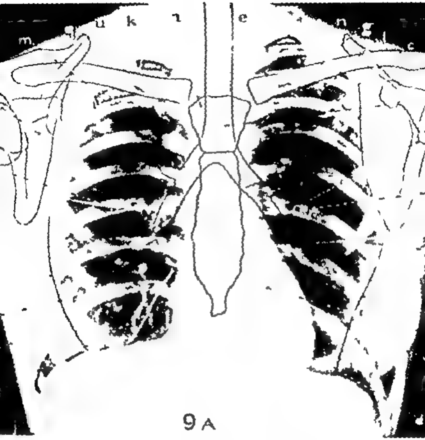
The lobes can be well defined by their anatomic distribution On the right side the major oblique interlobar fissure begins at the third vertebra posteriorly and extends down and anteriorly to reach the diaphragm about 3 cm from its most anterior attachment This demarcates the lower lobe posteriorly and inferiorly The horizontal minor fissure extends from the major fissure at about the point of the root of the lung anteriorly and crosses the chest from about the fourth rib at the axilla to reach the hilus at the level of the second rib anteriorly This demarcates the upper lobe above and the middle lobe below On the left side only one fissure is present It begins at a slightly lower point than that on the right and extends somewhat more anteriorly so that the anterior portion of the lower lobe reaches the anterior chest wall at the level of the diaphragm In the postero anterior view the upper and lower lobes overlap to a considerable degree above and the middle and lower lobes on the right side overlap to a considerable degree below On the left side the lobes overlap except for a small portion at the apex and an extremely small area at the base At the base a large portion of the left lower lobe lies behind the cardiac shadow an important consideration in roentgen interpretation The same is true of a small portion of the right lower lobe Although a very thin tongue of the right middle

[Normal chest continued on page 50]

Fig 9A —Postero anterior roentgenogram of the normal thorax with diagrammatic representation of the various anatomic structures superimposed Structures which are commonly visible are indicated by white lines and those not ordinarily clearly demonstrable by black lines Anatomic variations are included Identification of the shadows of the anatomic structures is of the first importance in diagnosis

a manubrium sterni occasionally visible in the mediastinum *b*, scapula *b′* humerus *c* anomaly of first rib which is bifid anteriorly *d* calcification of costal cartilage a normal variation *e* trachea *e′* bronchus in cross section The various branches of the bronchial tree are shown although they are not clearly visualized in the normal They overlie the hilus of the lung on either side *g* arch of aorta *h* heart *i* blood vessel in cross section note homogeneity and sharply rounded character *i′* blood vessel in longitudinal section *j* reflection of pericardium over inferior vena cava *k* apex of lung *l* infraclavicular area *m* right upper lobe *m′* right middle lobe *m′′* right lower lobe *n* left upper lobe *n′* left lower lobe *o* oblique interlobar fissure right not visible normally *o′* horizontal interlobar fissure often visible normally *p* oblique interlobar fissure left not visible normally *q* anomalous azygos lobe fissure, an extra small lobe formed by a branch of the hemiazygos vein of no pathologic significance note the characteristic falciform shadow with the dense inferior portion it is found only on the right side *r* anomalous inferior accessory lobe fissure separating an extra lobe at the base which may occur in either or both lungs it is fairly common appearing in approximately 10 per cent of normals *s* anomalous interlobar fissure on the left indicating the presence of an extra middle lobe *t* apical cap the reflection of the pleura *u* linear shadow accompanying second rib a normal line *v* breast shadow

[Normal chest *continued on page 44*]



9A

Fig 9B —Lateral roentgenogram of the normal thorax with diagrammatic representation of the various anatomic structures superimposed The commonly visible structures are indicated by white lines and those not so clearly seen by black lines The lettering conforms with that in Figure 9A

a body of the sternum the manubrium can be seen above separated by a cartilaginous gap in young children five or six nuclei may be visible *b* shadows of the scapulae seen on end *b* humerus and shoulder joint *c* trachea which may be seen fairly well in heavily exposed films as a broad band of lessened density *e* bronchus seen on end is designated by lower *e* *f* hilus shadow representing the root of the lung most of the density is caused by the pulmonary artery *g* ascending aorta *h* heart *i* blood vessel seen on end *i* blood vessels in longitudinal section *j* reflection of the inferior vena cava *m* right upper lobe giving a radiable area anterior to the heart *m* right middle lobe superimposed on the cardiac shadow *m* right lower lobe *o* oblique interlobar fissure *o'* horizontal fissure between middle and upper lobes The position of the fissures indicates the distribution of the various lobes on the right side On the left the oblique fissure extends somewhat more anteriorly below *v* breast shadows *w* right diaphragm higher anteriorly than posteriorly *w* left diaphragm lying somewhat lower than the right

[Normal chest *continued on page 46*]

9B

Fig 10 —Postero-anterior roentgenograms to show effects of respiration Both films were made at the same time under exactly similar conditions except for the respiratory phase

Fig 10A —Deep inspiration The diaphragms are retracted downward the intercostal spaces are wide and the lung fields are well aerated Bronchovascular linear markings are clearly apparent radiating from the lung roots separated from each other by air filled alveoli

Fig 10B —Deep expiration The diaphragms are markedly elevated the intercostal spaces are narrower and the heart is shorter and wider than in *A* The bases of both lungs are relatively dense and the vascular trunks are not clearly defined The lungs contain much less air and relatively more blood than in *A* hence the change in density and sharpness It is important to distinguish such normal changes from those due to pneumonia or atelectasis

Fig 11 —Contrast cardiogram left oblique anterior position Diodrast was injected into the cubital vein to reach the heart and large vessels At the moment this roentgenogram was made the right ventricle and pulmonary arteries had just become filled with the contrast material The identity of the linear markings of the lung with the pulmonary arteries is demonstrated *a* contrast medium in brachial vein *b* right ventricle dense from contrast medium *c* left ventricle dense because of overlapping of spine *d* truncus pulmonalis *e* left pulmonary artery *f* pulmonary artery branches which produce linear markings of lung (Courtesy of Dr Earl Miller University of California Hospital)

Fig 12 —Normal chest straight right lateral position *b* edge of scapula *c* sternum *e* trachea *f* carina *h* shadow of heart in lateral projection *h* posterior border of heart *i* pulmonary artery small branch seen on end *i* branch of pulmonary artery in longitudinal projection *m* right upper lobe of lung producing normal triangle of radiability anterior to large vessels *m* right middle lobe superimposed on cardiac shadow *m* right lower lobe *n* breast shadows *w* right diaphragm *w* left diaphragm *x* thoracic vertebrae

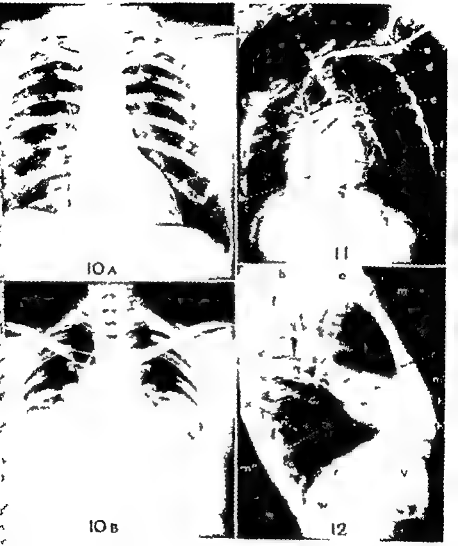

10A
11
10B
12

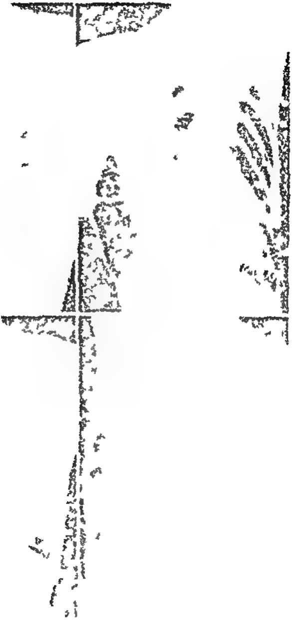
Fig 13 — Postero anterior view, upright position normal female *a* sternum near sternoclavicular joint projecting to right *c* anterior end of rib costal cartilage not ossified *c'*, bronchus on end producing circular area of rarefaction *f* hilus of right lung composed largely of the pulmonary artery *g* arch of aorta *i* pulmonary arteries longitudinal projection producing linear shadows in lung fields *k* apex of lung *m* right lower lobe lung appears less dense just beyond margin of breast shadow (*v*) because it is uncovered *n* left lower lobe below breast shadow (*v*) *u* reflection of skin over clavicle *x* end of transverse vertebral process superimposed on rib *z* area of apparent radiability representing segment of normal lung surrounded by blood vessels often mistaken for cavity

Fig 14 — Postero anterior view upright position normal female *f* left hilus shadow *i* blood vessel on end with round sharply defined appearance often mistaken for calcified lymph node *i* normal blood vessels longitudinal projection *k* apex of lung *l* subclavicular area *o* horizontal interlobar fissure between middle and upper lobes common in the normal lung *t* apical cap a pleural reflection Breast shadows and greater radiability of lungs beyond are as in Figure 13

Fig 15 — Right oblique position patient with partial funnel chest *a* junction of manubrium with sternum *b* scapula *b* head of humerus *d* calcifications of costal cartilages *g* arch of aorta posterior portion *g'* aortic window with aortic ectasia *v* breast shadow superimposed on heart *y* descending aorta and mediastinal tissues

Fig 16 — Left oblique position *a* sternum *b* scapula *c* trachea *c* right main bronchus *c'* left main bronchus Trachea and bronchi are visualized because of air content *f* hilus of right lung representing pulmonary artery and large bronchi *g* descending portion of aortic arch *g* aortic window *h* anterior right border of heart *h* posterior left border of heart *i*, left pulmonary artery *z* area of consolidation in lung

[Normal chest *continued on page 50*]



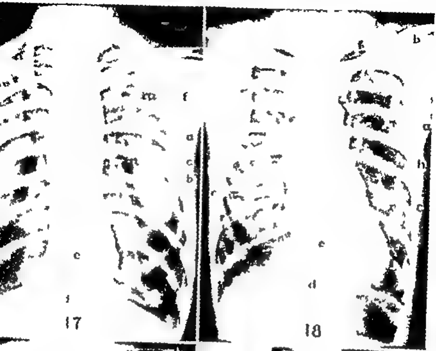
ANATOMIC VARIATIONS AND ARTEFACTS Numerous superimposed shadows produce confusing appearances in the roentgenogram some of which are shown here Stereoscopic studies lateral views and attention to technical details tend to minimize such shadows

Fig 17 —Effect of emaciation on shadows in the chest The patient was tall thin markedly asthenic and emaciated a shadow of scapula superimposed on the thorax b folds of skin on the back give a distinct density often mistaken for abnormality c area of greater radiability representing lung not covered by folded skin d diaphragms are low owing to asthenic build and some emphysema e large veins at base of right lung normal f calcification of first costal cartilage, normal in third decade calcification of other costal cartilages occurs somewhat later

Fig 18 —Asthenic patient a edge of scapula b shadow of sternocleidomastoid muscle laterally an area of increased radiability represents uncovered apex of lung c, nipple shadows common in women occasional in men these may be mistaken for metastases d diaphragms are low and their attachments in the form of linear vertical shadows due to emphysema e, branches of pulmonary artery h artefact from defect in intensifying screen

Fig 19 —Extrinsic shadow from braid of hair simulating pulmonary lesion b sternocleidomastoid muscle h shadow of braid both outside the chest and overlying the apex often mistaken for abnormality g end of first rib absence of calcification of costal cartilages causes apparent gap between rib and sternum i manubrium sterni projecting to left of aortic arch

Fig 20 —Shadows produced by particles in clothing Numerous nodular densities (h) apparently in the lung represent small polka dots in clothing not removed for examination Misinterpretation of such extrinsic objects must be avoided



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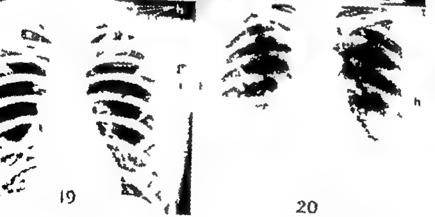

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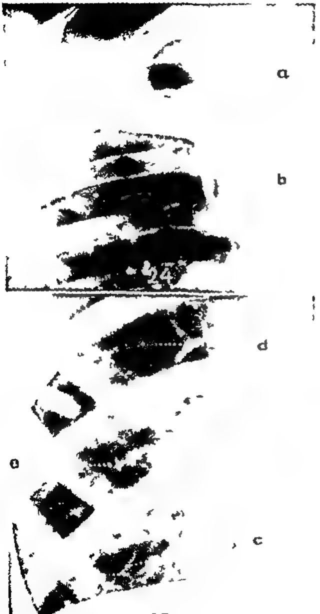
20

ANATOMIC VARIATIONS These consist largely of extra lobes and the interlobar fissures which accompany them. Two such anatomic variations are shown here Both figures represent small sections of the lung enlarged to bring out detail.

Fig 24—Azygos lobe An extra lobe separated from the right upper lobe in its medial portion by an anomalous branch of the azygos vein is found in about ½ per cent of normal individuals This forms a reflection of pleura around it which gives a falciform shadow (a) ending inferiorly with a plumb bob-shaped density (b) The importance of this observation lies largely in not mistaking it for an abnormality

Fig 25—Inferior accessory lobe. In approximately 10 per cent of normal individuals the lower lobe is divided medially to form an accessory lobe which may be uni or bilateral c interlobar fissure of right inferior accessory lobe extending obliquely from the diaphragm medially to the root of the lung The shadow is doubled owing to the obliquity of the fissure d horizontal fissure between right middle and upper lobes This is normal when it is approximately the thickness of a hairline as shown here The line is doubled because of the obliquity of the fissure e blood vessels of normal lung shown in increased detail They form a network of linear shadows throughout the lungs becoming fainter and narrower as they approach the periphery



25

ANATOMY OF THE TRACHEOBRONCHIAL TREE In these drawings of the major bronchi and their branches the terminology is adapted from that proposed by Jackson and Huber The numerical designation follows the plan of Boyden The trachea and major bronchial branches are designated by letter the segmental branches of the bronchi are numbered as proposed by Boyden It should be noted that there are minor differences in the numerical order from those recommended by the International Committee

Fig 26A —Drawing of frontal projection (adapted from Boydens work)

Fig 26B —Right lateral projection

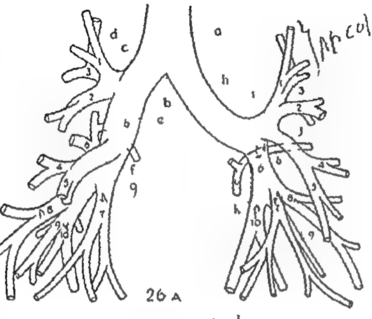
Fig 26C —Left lateral projection

a trachea *b* carina *c* right main bronchus *d* right upper lobe bronchus *e* right stem bronchus *f* middle lobe bronchus *g* lower lobe bronchus *h* left main bronchus *i* left upper lobe bronchus *j* lingular branch of left upper lobe bronchus *k* left lower lobe bronchus

Segmental bronchi right side *1* apical branch of upper lobe with two divisions *2* anterior branch with two divisions *3* posterior branch with two divisions *4* lateral branch of middle lobe *5* medial branch of middle lobe *6* superior branch of lower lobe *7* medial basal branch of lower lobe *8* anterior basal *9* lateral basal *10* posterior basal

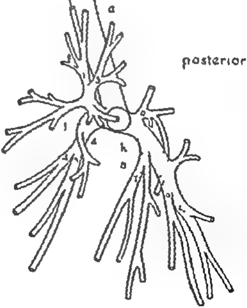
Segmental bronchi left side *1* and *3* apical and posterior branches of upper lobe bronchus arising together *2* anterior branch *4* superior lingular branch *5* inferior lingular branch *6* superior branch of left lower lobe *7* medial basal branch of lower lobe *8* anterior basal *9* lateral basal *10* posterior basal

[Bronchography Normal *continued on page 60*]



26 A

26 B



26 C

BRONCHOGRAPHY IN THE NORMAL CHEST Bron chograms made by instillation of contrast medium are highly important in the diagnosis of diseases of the lungs particularly those related to the bronchi Ordinarily it is not advisable to fill all of the bronchi simultaneously as shown in some of these illustrations Only one lung often only one main bronchus and its branches should be examined at one time By this means however the entire tracheobronchial tree can be directly visualized and clearly delineated in the roentgenogram and the localization of segmental pathology in the lungs established The numerical designation is from Boyden and the terminology is adapted from Jackson and Huber to give a segmental description as indicated in the drawings in Figure 26

Fig 27 —Bronchogram postero anterior view in a child both sides being filled at once Note the delineation of the lumen of the bronchus only partly filled with the contrast medium which coats its walls Only the major bronchi are filled

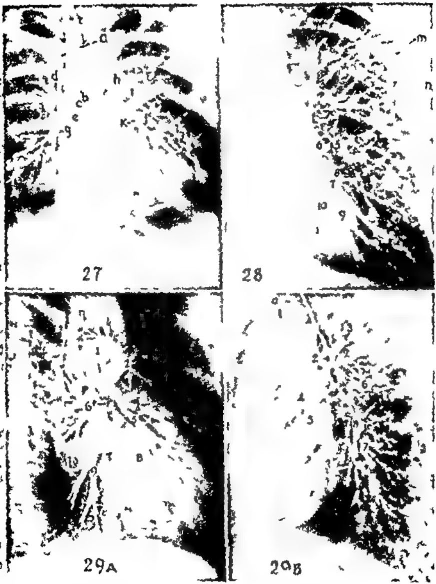
Fig 28 —Bronchogram normal left side only postero anterior view in an adult Note the arborization beyond the major bronchi into the smaller bronchioles A certain amount of this is unavoidable but should be minimized (Courtesy of Dr W H Ude C N Borman and E E Ahern St Mary s Hospital Minneapolis)

Fig 29A —Bronchogram right oblique view left bronchi only are shown

Fig 29B —Bronchogram left lateral view left bronchi only

a trachea *b* carina *c* right main bronchus *d* right upper lobe bronchus *e* stem bronchus *f* middle lobe bronchus *g* lower lobe bronchus *h* left main bronchus *i* left upper lobe bronchus *j* lingular branch of upper bronchus *k* left lower lobe bronchus *l* catheter for injection *m* arborization from filling of smaller bronchi and bronchioles *n* alveolar opacification *o* esophagus Small amount of contrast often is swallowed

1 and *3* apical and posterior branches of upper lobe bronchus arising together *2* anterior branch *4* superior lingular branch *5* inferior lingular branch *6* superior branch of left lower lobe *7* medial basal branch of lower lobe *8* anterior basal *9* lateral basal *10* posterior basal



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28

29A

29B

Positioning is of great importance in demonstrating all the bronchi and films made in the left anterior oblique or right posterior oblique views will best visualize the right bronchial branches. Lateral and postero-anterior views are also of great importance.

Fig. 30A.—Postero-anterior view, right side only, normal bronchogram.

Fig. 30B.—Left anterior oblique view to demonstrate the right segmental branches.

Fig. 30C.—Right posterior oblique view to demonstrate the right segmental branches. Note the arborization produced by the contrast medium extending into the smaller bronchioles and to some degree into the alveoli in the lower lobe.

Fig. 30D.—Right lateral view. Note the contrast medium in the parenchyma which effectually demarcates the right lower from the middle lobe.

a, trachea; *b*, carina; *c*, right main bronchus; *d*, right upper lobe bronchus; *e*, stem bronchus; *f*, middle lobe bronchus; *g*, lower lobe bronchus; *h*, left main bronchus delineated by a[n] *l*, catheter; *m*, arborization from filling of smaller bronchi [and] parenchymal opacification and demarcation of lower lobe.

1, apical branch of upper lobe with two divisions; *2*, anterior branch with two divisions; *3*, posterior branch with two divisions; *4*, lateral branch of middle lobe; *5*, medial branch of middle lobe; *6*, superior branch of lower lobe; *7*, medial basal branch of lower lobe; *8*, anterior basal; *9*, lateral basal; *10*, posterior basal.

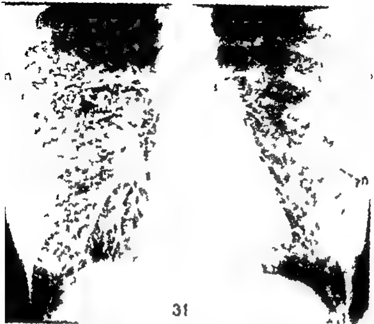
[Bronchography, Normal *continued on page 64*]


30A
30B
30C
30D

Fig 31—Postero anterior view with bilateral filling in a normal adult The entire tracheobronchial tree is well shown Not only the smaller bronchi but the alveoli have been opacified in many areas The latter should be avoided if possible It usually results from a contrast medium which is too fluid from coughing or from partial atelectasis Note the typical arborization (*m*) in the right lung as the bronchioles and alveoli are filled Extensions into the alveoli as shown especially on the left side (*n*) may remain for long periods

Fig 32—Residual contrast after bronchography Iodized oil had been introduced earlier in the right lung and somewhat more recently in the left The faint residual shadows produced by the remains of the contrast medium are well shown in the right upper lobe (*p*) Such shadows may easily be confused with abnormalities of the lung On the left side the clumps of iodized oil in the alveoli are well shown (*n*) They can be distinguished from the usual effects of disease by their metallic appearance and the finely stippled shadow which contrast medium within the alveoli produces Nevertheless if absorption occurs the distinction between such residual shadows and multiple nodular lesions in the lungs may be difficult

(Courtesy of Dr W H Ude C N Borman and E E Ahern St Mary s Hospital Minneapolis)



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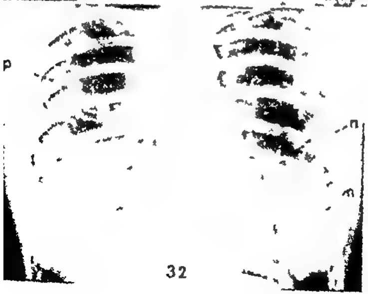

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PHYSIOLOGY OF THE RESPIRATORY TRACT Th peculiarities of the structure of the thoracic cage and its contents give rise to certain phenomena which bear importantly c the interpretation of the x ray findings in diseases of the chest The normal and pathologic physiology of the respiratory tract is much too complex to deal with in any detail in this volum Nevertheless certain salient considerations should be mentioned

Although the tracheobronchial tree tends to maintain a ce tain degree of rigidity at least in the larger branches there is distinct difference in the diameter of the structures during th phases of inspiration and expiration During inspiration the d ameter of the trachea and of most of the bronchi is distinct larger than during expiration It is important to bear this in m because of the effect of partial obstruction of the bronchi on th lungs Foreign bodies tumors and other obstructive mechanism which may not fill the trachea or bronchus during the phase c inspiration often completely obstruct the same structure durin the phase of expiration making it possible for air to be inhal but not exhaled Furthermore since inspiration is a relative *active process while expiration is a passive one* it is easier f air to get into the lungs than to get out On these mechanism depends the phenomenon of obstructive emphysema which pr duces increased radiability of the affected portion of the lun during expiration This is an important factor in the diagnosis foreign bodies and tumors of the tracheobronchial tree

The circulation to the lungs is so rich that absorption of gas occurs with great rapidity *even nitrogen* being capable of a sorption within a few hours Because of this and possibly al because of the piston effect of mucus in the bronchi whi tends by ciliary action to expel air obstructive atelectasis m develop rapidly When the bronchus is occluded so that air ca not enter the alveolar walls collapse shortly thereafter and t phenomenon of so called massive collapse or atelectasis th takes place

It is important to observe that both emphysema and atele tasis which produce completely different pictures as far density is concerned may arise from the same etiologic fact

at different stages of the process Thus a foreign body at the outset may produce obstructive emphysema because it is only incompletely obstructing the bronchus As time goes on with the development of inflammation swelling of the mucosa of the bronchus and collection of debris the obstruction may become complete following which atelectasis will supervene Exactly the same thing occurs with such lesions as bronchial asthma in which multiple plugs may appear in many of the small bronchi producing emphysema the obstruction occasionally becomes complete and atelectasis replaces the emphysema A similar process may take place with tumors and bronchostenoses

The pressure in the pleural cavity is normally less than atmospheric pressure It is more negative during inspiration than during expiration The negativity of the pressure is maintained by the elasticity of the lungs which tend to retract toward their attachments at the roots

Because the thorax is a closed cage changes in the intrathoracic content such as occur when one lung becomes either distended by emphysema or shrunken by atelectasis will produce marked changes in the position of the mediastinum and diaphragms and in the size of the intercostal spaces For example with massive atelectasis of a lung the intrapleural pressure on that side may be reduced to as low as minus 40 while the negative pressure on the opposite side remains the same There is naturally a powerful tendency for the mediastinum if it is not fixed to shift to the side of the lesion Similarly the diaphragm on that side ascends because of the sharp difference between intrathoracic and intra abdominal pressure and there is a greater tendency for the chest wall to collapse All of these phenomena are of the first importance in diagnosis

Changes in intrathoracic pressure as between inspiration and expiration must also be considered In the case of unilateral obstructive emphysema for example during quiet respiration the increased intra alveolar pressure of the involved lung tends to displace the mediastinum toward the normal side During expiration the mediastinum shifts even more conspicuously to the normal side because the ordinary increase in intra

pulmonary pressure on the normal side is less than the more marked increase which occurs on the abnormal side. During *inspiration the mediastinum is restored to some degree* toward its normal position because the pressures tend to be somewhat more equalized. A pendulum motion therefore occurs with a swing toward the abnormal side during inspiration and toward the normal side during expiration. A similar pendulum motion *occurs in obstructive atelectasis with the difference* that at the outset, because of the markedly diminished pressure in the atelectatic lung, the mediastinum is displaced toward the abnormal side. In quiet respiration the mediastinum is displaced away from the normal side. In deep inspiration and expiration, *however, the phenomenon resembles that described* above. The pendulum motion may be exaggerated if the patient expires and then sniffs.

The circulation to the lungs is such that changes in intrathoracic pressure on one side or the other produce marked dif*ferences in the amount of blood* which passes through the involved lung. This accounts in a large part for many of the changes in density which occur in emphysema on the one hand, and in atelectasis on the other. In cases of emphysema *the intra*pulmonary pressure is greatly increased because of distention, and the result is a tendency for the involved lung to become ischemic, the blood being able to circulate through these vessels to a lesser degree than on the normal side. In such circumstances the normal lung may appear to have an increased vascularity which is due simply to the shunting of the blood. Exactly the contrary occurs in atelectasis. Here the markedly reduced intrapulmonary pressure causes a shunting of the blood toward the side of the lesion, and no doubt this increased flow of blood *accounts in large part for the greatly increased* density of the atelectatic lung. Compressive atelectasis, such as occurs with pneumothorax, gives a very different picture because in this condition not only the air but also the blood is compressed out of the lung. As a consequence ordinary compressive atelectasis does not materially increase the density over that of the normal lung unless some severe pathologic process was present in the lung before the institution of the pneumothorax. Again the normal

lung appears congested owing to the shunt of the circulation

The capillaries of the lungs are relatively permeable As a result edema probably occurs more readily in the lungs than elsewhere This early sign of many lesions is readily visualized

The pleural space although spoken of as a cavity is essentially a potential space only Nevertheless its physiology is of the first importance and determines in large measure the curious distribution of pleural effusions within the thorax the position assumed by air in the pleural cavity and the changes in appearance of the various lobes of the lungs under varying conditions Because in normal conditions there is constantly a negative pressure within the pleural cavity the thorax does not act as a simple container The tendency of the lungs to retract toward the mediastinum produces a distinctive pull of the visceral pleura away from the parietal pleura At the same time the phenomenon of capillarity is set up since these are two smooth surfaces in close contact As a result of these factors fluids and air in the pleural cavity do not distribute themselves as might be expected if gravity were the only factor involved Gravity of course exerts an important effect but the effect is neutralized to a considerable degree by the relative differences in potential negative pressure in various portions of the thorax Although the pleural cavity communicates throughout and therefore the pressures within it are equalized the potential negative pressure may be much greater well out at the inferior costophrenic sinus than for example in the middle of the thorax Such differences are largely responsible for the typical curve of pleural fluid The negative pressures however depend on a retention of the elasticity of the lung Changes in the lung such as occur with chronic edema fibrosis emphysema and atelectasis eliminate most of the elasticity thereby distorting the typical distribution of fluid or air in the pleural cavity

Finally it should be noted that the lung is fixed at the root but is readily mobile elsewhere unless bound down by adhesions Obviously the presence of adhesions either around the mediastinum or in the peripheral portions of the pleura will modify greatly the influences which the physiologic factors already cited will exercise

segments are often deprived of their blood supply sufficiently to produce sequestration followed by cystic degeneration bronchiectasis and abscess formation

2 Pulmonary arteriosclerosis

A primary disease of the pulmonary arteries which may be the result of prolonged hypertension or due to a more specific disease such as syphilis produces marked changes especially thickening of the pulmonary arteries They become distended, their shadows are far more prominent than normal and their pulsations are greatly increased Such lesions of the arteries commonly proceed to obliterating angiitis of the smaller pulmonary vessels so that in the later stages there is diminution of the vascular shadows in the periphery of the lung but with a secondary great increase of their size centrally Almost invariably associated with such a condition are distinctive changes in the cardiac outline indicating a right heart enlargement, so called cor pulmonale

3 Arterial disease secondary to cardiovascular disorders

With many congenital lesions in the heart particularly patent ductus arteriosus and interatrial septal defects there is a left to right shunting of blood with a resultant increased pressure in the pulmonary circulation so that the pulmonary arteries become exceedingly prominent In pulmonary stenosis the reverse is true, the linear shadows of the blood vessels being greatly decreased in size As a result of pulmonary stenosis there may be a compensatory dilatation of the bronchial arteries which may eventually produce some linear markings in the lungs These are usually much narrower than those caused by the normal pulmonary arteries and run in much straighter lines rather than radiating from a central point

4 Passive congestion

Dilatation of the pulmonary veins almost always accompanied by enlargement of the hilus shadows of the lungs occurs with cardiac failure Dilatation may be the result of recognizable cardiac disease and may also occur without apparent cardiac disease caused by sudden overloading of the circulation

and similar processes A distinctive difference between the shadows resulting from dilatation of the pulmonary veins and those caused by enlargement of the pulmonary arteries previously described can usually be made out the veins are less sharply defined and there is a tendency to diminution in the aeration of the lungs in the areas involved

5 Pulmonary edema

As a result of cardiac failure neurogenic disorders disease of the kidneys hypoproteinemia of various origins and surgery and especially as a result of the overloading of the circulation, fluid within the alveoli is increased Although primarily vascular in origin the manifestations extend beyond the vessels into the lung parenchyma Edema may result from passive congestion but also takes place independently

6 Pulmonary infarcts

Infarction of the lung is another lesion which is primarily the result of a vascular disorder but affects principally the lung parenchyma Hemorrhagic exudation into the alveoli results from thrombosis or embolism in a pulmonary vessel thus producing a very extensive shadow in the lung Embolism without infarction may cause symptoms but no increased density in the lung in fact the area of involvement may show an increased degree of radiability with absence of all vascular shadows in that area

C Tracheobronchial Lesions

1 Bronchitis

Inflammatory lesions affecting the bronchi themselves such as acute and chronic bronchitis show relatively little change in the roentgenogram Commonly at least in the acute stages active congestion of the vessels causes a distinct increase in the size of the vascular markings The bronchi often become more distinct because they are filled with purulent fluid and then are hardly distinguishable from the vessels surrounding them In the acute stages of bronchitis some fine mottling of the lung may therefore be present In chronic bronchitis the so-called linear markings appear to be distinctly increased and

thickened probably owing to changes in the walls of the bronch and to the peribronchial infiltration which results

2 Bronchiolitis

Involvement of the bronchioles may occur as an acute chronic process The terminal bronchiole may be filled wi purulent exudate with a tiny patch of pneumonia around it, it may become fibrotic and organized in a more chronic sta Numerous fine nodular lesions result which resemble the vario miliary lesions considered under parenchymal diseases (p 64

3 Bronchiectasis

Dilatations of the bronchi producing cavity like areas may l present There is a great variability in these manifestations The are more common in the lower than in other lobes but may occu in the upper lobes depending on the origin of the bronchiectasi Usually they are bilateral although unilateral unilobar an even segmental bronchiectasis may occur In the last mentione types evidence of bronchostenosis from either tumors or inflam matory lesions can often be demonstrated Bronchography is c the first importance in the diagnosis of bronchiectasis Excep in the most severe cases it is risky to base the diagnosis o bronchiectasis on simple films of the lungs and it is virtuall impossible to exclude minor degrees of bronchiectasis withou using a contrast medium

4 Cystic bronchiectasis

A type of bronchiectasis in which the smaller bronchi are dilated and therefore have thinner walls and larger cavities than is usual is commonly referred to as cystic bronchiectasis Al though some of these cases may be congenital the vast ma jority are acquired probably during early life They present the picture of multiple small honeycomb like air sacs through out the lung Bronchography is of the utmost value in determining the nature of the condition

5 Bronchial asthma

Within the bronchi bronchography reveals characteristic mul tiple obstructions which are the result of the hardening of exces sive mucus into plugs The lumens of the bronchi of the third

nd fourth order are commonly obliterated in widespread areas f the lungs so that a contrast medium discloses a snub nosed vell defined obstruction in many bronchi

Secondary changes in the lung parenchyma are extremely common in the presence of incident bronchial lesions In bron chiectasis for example cavitation and similar lesions of this type occur they are discussed under parenchymal diseases In bron chial asthma also there is almost invariably a good deal of em physema and often some atelectasis

6 Bronchostenosis inflammatory

Constrictions of the bronchi may occur with diseases such as tuberculosis and nontuberculous abscess or as end results of trauma Although the stenosis itself may be demonstrated by bronchography or body section roentgenography the major roentgen findings depend on the secondary parenchymal mani festations i e emphysema atelectasis abscess formation bron chiectasis and carnification

7 *Tumors*

Both benign and malignant tumors occur particularly the so called benign adenoma and carcinoma As in bronchostenosis the tumor itself may be demonstrable in the lumen of the bron chus but the most important changes occur in the lungs second ary to the obstruction

8 Foreign bodies

Metallic foreign bodies are easily recognized Nonmetallic foreign bodies can be determined by the secondary changes in the lungs particularly emphysema and atelectasis

9 Congenital defects

Anomalies and anatomic variations in the development and distribution of the bronchi are exceedingly common They may or may not be associated with anomalies of the vascular supply of the lungs as well Absence or maldevelopment of a bronchus is not at all rare If a main bronchus is involved the lung may be entirely lacking (agenesis) or rudimentary The mediastinum will be displaced toward the side of the underdeveloped lung to a marked degree That hemithorax will be exceedingly dense

while the normal lung will be greatly expanded and will herniate toward the abnormal side. Anomalous development of smaller bronchi may result in a cyst of the lung with its characteristic appearance. Necrotic or cystic areas in the lung may develop as a result of an anomalous bronchial distribution together with anomalous or completely absent blood supply to the portion of the lung. Specific bronchogenic cysts not connected with the lung and usually not communicating with the bronchial tree occur in the mediastinum. These are essentially duplications and often cannot be distinguished from esophageal and gastric cysts occurring in much the same location and having much the same appearance.

D. Parenchymal Lesions

Abnormalities of the parenchyma of the lungs may be classified according to certain pathologic processes which should be ascertained to clarify the nature of the underlying disease. They can best be classified under the following headings:

1. Emphysema.

The observation of emphysema—local, unilateral or general—is of the first importance in determination of the presence of abnormalities in the lung. The diagnosis is based largely on the low position of the diaphragms, the increased width of the interspaces, the tendency to an elongated narrow central shadow and the increased prominence of the linear markings of the lung with increased spaces between the markings. The root shadows are usually somewhat increased with emphysema. The actual radiability of the lungs is distinctly increased. This is relatively easy to determine when the process is unilateral, thus permitting comparison with the opposite normal lung. When the process is bilateral a general knowledge of the normal radiability of the lungs with a certain type of exposure must be depended on. One should bear in mind, however, that variations in exposure of the roentgenograms and variations in the thickness of the chest wall will produce striking variations in radiability of the lungs. The density of the central shadow of the thorax may be used as an index for comparison of penetration, and from that the effect

f increased penetration in producing the appearance of in reased radiability of the lungs can be determined [An approxi nation of expiration to inspiration is characteristic of emphysema nd can be determined best by fluoroscopic examination There vill be a marked diminution in the motion of the diaphragms urthermore the degree of radiability of the lungs will change ery little from one phase of respiration to the other]

By fluoroscopic examination the degree of motion of the dia phragms the shift of the mediastinum from one side to another and the effects of expiration on the density of the two lungs can be studied Such observations are highly significant in the detection of emphysema either local or generalized

a) Localized emphysema

Partial local obstruction of a bronchus such as may occur with tumors inflammatory stenoses pressure defects and con genital abnormalities of the bronchi produces localized disten ion of the lung Such localized dilatations may be blebs under the pleura bullae within the lungs as occur secondary to long tanding emphysema with ectasia of the alveoli or actual bal ooning of the lung

b) Unilateral emphysema

Emphysema of one lung is most commonly caused by a for ign body in the bronchus and can best be demonstrated during the phase of expiration (The phenomenon of obstructive em physema has already been discussed) A similar change takes place with tumors of the bronchi and in occasional cases of bronchial asthma when the bronchi on one side are more ob structed than those on the other producing a difference in expi ration

Outstanding characteristics of unilateral emphysema are the displacement of the mediastinum away from the side of the lesion and its pendulum motion during deep respiration

c) Bilateral emphysema

A foreign body in the trachea which is only partially obstruc tive may produce emphysema of both lungs by the same mecha nism as that described previously A paradoxical change in the size of the heart which apparently becomes smaller in expiration

than in inspiration and the inability of the diaphragms to move upward during expiration characterize the lesion

Bronchial asthma is a common cause of bilateral generalized emphysema following partial obstruction of many of the smaller bronchi. Silicosis and other fibrotic lesions of the lungs in which there is obstruction around the mediastinum may produce bilateral emphysema. There is also a generalized nonspecific emphysema most often observed in older individuals the cause of which is unknown

d) Compensatory emphysema

As a result of atelectasis either obstructive or compressive involving portions of the lungs compensatory distention of the remaining lung segments may develop. The changes in intrathoracic content may thus be equalized. Such compensatory phenomena are particularly apt to occur in children. For example atelectasis or fibrosis of the right upper lobe may cause striking distention of the middle and lower lobes which finally fill the entire hemithorax. Similarly marked atelectasis or fibrosis of one lung often causes emphysema of the contralateral lung which then expands into the opposite hemithorax even herniating through the mediastinum

e) Cystic areas in the lung

With congenital or acquired air-cysts of the lung large areas of the lung field may be emphysematous that is there is ectasis of the alveoli which break down so that a well encapsulated area of radiability results. This resembles cavitation in the lung but differs in that there is no fluid and no particular capsule except for the surrounding area of somewhat atelectatic lung. These areas may be single or multiple

B Atelectasis

A common manifestation of many pulmonary diseases either as the primary change incident to the disease or as a complication of another process is obstructive atelectasis. It may be defined as an airless condition of the alveoli in which the alveolar walls are in close juxtaposition because of obstruction to the inflow of air. It should be noted that atelectasis does not exclu

the presence of some fluid within the alveoli and that in the presence of obstructive atelectasis there are usually some retention of fluid within the bronchi and a greatly increased relative amount of blood in the affected portions of the lung As a result of atelectasis the lung density increases greatly, probably owing to the increased amount of fluid in the lung rather than to the increased density of the actual lung tissue The nature of compressions of the lung such as occur with a pleural effusion or pneumothorax is quite different although atelectasis may be produced Such compression excludes both blood and air from the lung and therefore produces a different picture

Compensatory emphysema of the remaining portions of the lung is common with atelectasis

a) Localized atelectasis may be due to obstruction of a small bronchus from such lesions as tumor localized foreign body and inflammatory stenosis Such atelectatic areas may be either single or multiple and they commonly involve those segments of the lung which correspond to the distribution of the bronchi

b) Massive atelectasis refers to involvement of an entire lobe or an entire lung and most often results from obstruction of one of the larger bronchi as occurs with tumor or foreign body or of many of the smaller bronchi scattered throughout the lung as occurs with postoperative massive atelectasis and bronchial asthma In some cases of pneumonia especially in children atelectasis is present at the onset or occurs as a complication

The displacement of the mediastinum and heart toward the side of the lesion the upward shifting of the affected diaphragm and the narrowing of the interspaces are important signs of unilateral atelectasis,

c) Patchy atelectasis

Multiple areas of density may be observed diffusely scattered through both lungs They are often associated with asthma owing to irregular obstruction of the bronchi from mucus plugs It should be noted that in asthma one may find either emphysema or atelectasis or both depending on whether the plugs in the bronchi are completely or partially obstructive

3 Edema of the lungs

a) Edema has already been discussed under vascular changes Regardless of the cause a small amount of fluid accumulating in each of the alveoli may give a fine, mottled appearance to the lung When present in a large quantity a massive homogeneous density is produced It is notable that edema seems to affect the inner two thirds of the lung field rather than the very outer portion which tends to maintain its aeration This is often significant in differential diagnosis

b) Inflammatory fluid accumulates in the lung especially in severe cases of pneumonia so that the alveoli throughout both lungs may be filled to a considerable extent although the actual pneumonia is more localized

4 Consolidations

Areas of density of varying degrees sizes and locations may be due to almost any type of inflammatory process These areas result from a replacement of air in the alveoli by inflammatory tissue or fluid and are most conspicuous in the pneumonias They are likely to be fairly large and homogeneous and segmental in localization. In the earliest stage of consolidation or atelectasis there is often increased visibility of the air filled bronchi which stand out in contrast to the decreased radiability of the exudate filled lung parenchyma around them

5 Pulmonary infiltration

Increases in density accompanying the linear markings of the lungs are common in many diseases Such parenchymal shadows are most characteristic of pulmonary tuberculosis but may also occur with nonspecific fibrosis interstitial pneumonia bronchiectasis silicosis and many other inflammatory and traumatic processes of the lungs They differ from ordinary consolidations in the tendency to a linear pattern, the lack of great density and the rather hard sharply defined shadows

6 Fibrosis

Increased fibrous tissue in both lungs frequently causes rather diffuse accentuation of the linear pattern of the lungs It is most characteristic of pneumoconiosis but may also occur with interstitial pneumonia tuberculosis and any other lesions which

tend to cause increase of fibrous tissue in the lungs Some increase in the linear pattern occurs normally with age no doubt related to repeated respiratory infections A similar process which is almost indistinguishable may occur with some of the lymphatic lesions such as those resulting from erythema nodosum sarcoidosis leukemia polycythemia and the reticuloendothelioses Fibrosis of the lungs ■ an important feature of the lung findings associated with cystic fibrosis of the pancreas in young children Massive fibrosis of the lungs producing tumor like densities may occur with pneumoconiosis or with lipoid pneumonitis

7 Tumor

Masses resembling consolidations but distinguished by an expanding outer border may be observed in the lung These may be due to actual tumor growth in the lung most commonly seen in primary carcinoma metastases and lymphoblastomas The shadow is due to the replacement of air in the alveoli by tumor tissue In some instances the masses are indistinguishable from chronic consolidations and tuberculosis of the nodular type but the shadows of most tumors are so sharply defined so uniform in density and present such obviously rounded outer borders indicating a growing mass that the diagnosis can be established More diffuse tumor invasion occurs with multicentric alveolar cell carcinoma and with pulmonary adenomatosis visualized as generalized often irregular masses in both lungs

8 Nodulations

Nodular lesions in the lungs may be local or generalized They may be very small or quite large The most striking nodular lesions are of course those associated with miliary tuberculosis in which numerous tiny densities are widespread throughout both lungs A similar process however may occur with pneumoconiosis metastatic tumors and sarcoidosis With acute bronchiolitis multiple small nodular areas may be present probably caused by purulent material accumulated in the terminal bronchioles and surrounded by a small area of pneumonia

Larger nodules occur with diffuse metastases from malignant tumors multiple small abscesses of the lungs multiple small in

farcts bronchopneumonia and the round focus nodular type of tuberculosis The nummular form of tuberculosis which may be single or multiple is usually characterized by associated changes which permit its identification In certain instances of pneumonia the shadows may present a nodular form

Solitary nodules occur in the lung as a result of numerous causes such as tuberculoma other granulomas inspissated ■ fibrosed cyst of the lung, peripheral adenoma hamartoma solitary metastasis and peripheral carcinoma The presence or absence of malignancy in such a nodule is of the first importance in differential diagnosis Very often this differentiation cannot be made but evidence of the nodule should lead to further investigation sometimes an exploratory operation with biopsy being necessary

9 Cavitation

Areas of tissue destruction usually but not necessarily containing both gas and fluid are seen in the lungs There is a shadow of greatly increased radiability containing no lung markings The interface between fluid and gas can be demonstrated with the patient in the upright or lateral decubitus position Such cavities are usually a result of tuberculosis nontuberculous pulmonary abscess, fungus infections bronchiectasis abscess secondary to carcinoma of the lung and communicating lung cysts either acquired or congenital Rarely echinococcus cysts cause a fluid level in the lung Dermoid cysts, in rare instances cause what appears to be a fluid level but ■ in fact due to the fat within the cyst which floats to the top with the patient upright and demonstrates a difference in density between it and the remaining contents of the cyst

Cavities must be distinguished from local areas of emphysema pneumatoceles subpleural bullae and localized pneumothorax The presence of fluid is helpful The thick wall and associated consolidative or infiltrative changes commonly present also permit the distinction to be made

10 Calcifications

Areas of increased density characterized by a stippled, non

homogeneous shadow usually with an irregular outer border and with much greater density than that of any other type of pulmonary lesion can usually be recognized as being due to the deposition of calcium These are most often seen following tuberculosis, but other lesions, including histoplasmosis in particular and coccidioidomycosis and old nontuberculous cavities probably cause similar calcifications They may be localized to a small area or scattered throughout both lungs They are often associated with calcium deposition in the lymph nodes around the peribronchial area and in the peritracheal region Localized calcification within a nodule suggests that it is inflammatory particularly if the calcification appears in ringlike fashion If the calcification is stippled the possibility of hamartoma a benign tumor of the lung should be considered Densities characteristic of bone occasionally occur in sarcomatous metastases Calcifications occur in the pleura also they can usually be distinguished by their large size flat appearance and great density at the periphery

11 Foreign bodies

Opaque foreign bodies such as metallic objects in the lung are readily recognized by their density Vegetable particles pieces of wood and other types of nonmetallic foreign bodies may not be visible even within the lung field Occasionally one may see the density of a structure such as a bean within the trachea or bronchi when it is just properly projected against the air within the organ Generally speaking if the foreign body is nonopaque the diagnosis must depend on secondary changes produced in the lungs such as emphysema atelectasis abscess and carnification

12 Displacements and compressions of the lungs

Changes of pressure in one or both pleural cavities may be the result of pneumothorax pleural effusion tumors of the pleura or lung atelectasis fibrosis or emphysema of the lung These changes are manifested by elevation or depression of the diaphragm and displacement of the mediastinum toward or away from the side of the lesion depending on the nature and position of the process One lung may be displaced and compressed by a pleural process for example while the contralateral lung over

distends for compensation The normal lung may then herniate into the contralateral hemithorax Shifts in the position of the mediastinum and diaphragms during respiration must be observed because they are of the first importance in diagnosis of obstructive emphysema obstructive atelectasis pleural effusion and pneumothorax

SEASES OF THE MEDIASTINUM The structures cupying the central portion of the thorax the trachea main onchi heart great vessels and other constituents of the medi tinum may be affected by disease which is primary in these gans or secondarily by processes in the lungs and pleura

Primary lesions of the mediastinum may be the result of auma inflammation or tumor formation Rupture of a bronchus ng or esophagus whether from trauma or from disease may use emphysema of the mediastinal tissues by extension of the r along the vascular trunks into the mediastinum Emphysema the cervical tissues is often associated Fluid in the mediasti um also results from rupture of the esophagus bronchus or ng or from extension of inflammatory processes Localization ith abscess formation is not uncommon in the mediastinum

Masses in the mediastinum that is local enlargements of the ntral shadow may result from abnormal enlargements of in insic structures such as the thymus thyroid and aorta and from *mefactions of the lymph nodes which surround the trachea and* onchi The lymph nodes may be enlarged by inflammation ich masses are usually caused by tuberculosis and less fre uently by sarcoidosis and erythema nodosum Many of the fun is infections also cause lymph node tumefaction Calcification *the lymph nodes usually signifies a first infection tuberculosis* ut may also be due to histoplasmosis. It is important to distin uish small lymph node enlargements from the shadows of nor al blood vessels

The lymphoblastomas including Hodgkins disease lympho rcoma, aleukemic leukemia and leukemia are important causes f lymph node masses in the mediastinum Frequently the medi stinal lymph nodes are the first group involved and may repre nt the only lesion They are among the commonest sites of ocalization of lymphoblastoma

Tumors including neurofibroma fibroma and fibrosarcoma poma thymoma and sympathicoblastoma must be distinguished y differences in location size and associated changes Congenital ronchogenic and gastric cysts dermoid cysts and teratoma also

occur Tumors of the esophagus may manifest themselves in the mediastinum

It should be noted that mediastinal empyema–paravertebral abscess and tumors around the thoracic spine cause shadows simulating intrinsic mediastinal lesions These can usually be distinguished in oblique and lateral positions and by further roentgen study of the appropriate structures

The secondary effects on the mediastinum of changes in the lungs and pleura are often crucial diagnostic features of the disease process Many of these have already been discussed Generally speaking with atelectasis fibrosis and other constrictive processes in the lungs or pleura the mediastinum is displaced toward the side of the lesion With emphysema pneumothorax pleural effusion and massive expanding tumors of the lungs or pleura the mediastinum is displaced away from the abnormal side The effects of various lesions on the motion of the mediastinum have been discussed It should be noted that mediastinitis pericarditis and pleuritis may cause fixation of the mediastinum to the extent of eliminating all motion and preventing displacement

Herniation through the mediastinal tissues either anteriorly or posteriorly will occur when there is excessive pressure in one hemithorax as with massive pneumothorax or extreme unilateral emphysema or when there is marked diminution of pressure on one side as with massive atelectasis or extreme fibrosis of one lung Either the pleura alone with air in it as in pneumothorax protrudes through to the opposite side or the whole lung extends through the mediastinal defect

DISEASES OF THE PLEURA The chief lesions involving the pleura which are of interest from the roentgenologic standpoint are (1) edema and thickening of the pleura such as occurs with acute fibrinous pleurisy before the development of pleural effusion (2) pleural effusion of any origin (3) chronic pleural thickening and adhesions (4) pneumothorax (5) calcifications and (6) tumors

It should be borne in mind that in many cases of pleurisy there may be no x ray changes whatever Complete synechia of the pleura may cause no changes in the roentgenogram other than a slight decrease in radiability of the lung Changes in the pleura however may be manifested by reduction in aeration of the lung on the involved side owing to diminished expansion caused by pleural thickening A slight increase in density throughout the lung field may also result from generalized pleural thickening

Fluid in the pleural cavity regardless of its origin and character gives a striking and diagnostic picture The character varies according to etiology For example hemorrhagic effusions occur with trauma tumor infarct and tuberculosis Purulent and serous fluids are usually the result of infections either primary in the pleura or secondary to tuberculosis or pneumonia of the lungs Transudates may be associated with congestive cardiac failure constrictive pericarditis disease of the kidneys cirrhosis of the liver obstructions in the mediastinum from masses or adhesive processes and with pleural tumors

Regardless of the nature of the fluid the density of the shadow is much the same Differences in distribution and in the shift of fluids depend somewhat on the character of the fluid With the development of fibrin adhesions are produced which may eventuate in encapsulation These are usually the result of empyema but may occur with tuberculosis and are not uncommon in long standing cases of heart failure

Air in the pleural cavity results from either spontaneous or traumatic rupture of the lung Pneumothorax occurs spontaneously in apparently normal individuals but is most commonly associated with tuberculosis The introduction of gases into the

pleural cavity for diagnosis or therapy must always be che by fluoroscopic and radiographic examination Usually u to the pressure factors in the thorax small amounts of gas in the pleura are more readily demonstrated in expiration than i inspiration The same is true of mediastinal hernia induced by massive pneumothorax

Calcification of the pleura may follow trauma with the p duction of hemothorax or develop in old areas of tuberculous a nontuberculous empyema The appearance is bizarre because the irregular deposition of the plaques of calcium

Mesothelioma occurs as a primary tumor of the pleura but rare It usually produces masses on the pleural surfaces and se causes pleural effusion Such tumors in an early stage are w localized but soon involve large areas of the pleura Seconda involvement of the pleura from lung and mediastinal tumors common Effusions often hemorrhagic may be the chief ma festation

The pleura is secondarily involved in many pulmonary d eases and the pleural changes may be helpful in different diagnosis

INTERPRETATION OF ROENTGENOGRAMS OF TH CHEST A careful analysis of the results of fluorosco and roentgenographic examination of the chest is necessary f proper interpretation To obtain the most value from the roe genogram of the chest it should be observed in an orderly rout and certain points should be recorded In general comparis should be made between the two sides of the hemithorax and al with the normal roentgen appearance of an individual of simil habitus

A In postero anterior views the following specific poi should be observed (1) Position of the trachea (2) Position the mediastinum heart and large vessels in inspiration and ex ration (3) Position of the diaphragms (4) Width of the cos interspaces (5) Relative size position and density of root sha ows of the lungs (6) Degree of radiability of the two lungs inspiration and expiration (7) Size intensity and position

ronchovascular markings Changes in these shadows in various ortions of either lung must be observed and their density compared with the remaining normal portions of the lungs or with he standard normal chest Differences in size and intensity of hadows caused by the vascular trunks in the three divisions of he lung should be observed Absence of vascular shadows or ide separation of one linear marking from another is of considerable importance (8) Local changes of density in the lung The character of such areas of increased or decreased density should be recorded according to the following scheme (*a*) degree of density (*b*) sharply demarcated or hazy (*c*) nodular nummular linear or infiltrating (*d*) homogeneity or lack of uniformity (*e*) rounded or irregular shape (*f*) uniformity or lack of uniformity of size (*g*) number of lesions present (*h*) lobar or lobular distribution (*i*) position of density (*j*) presence of cavitation (*k*) presence of calcification (9) Changes in the peripheral pleural shadow (10) Changes in position and density of interlobar fissures (11) Adhesions to the diaphragm (12) Clarity of the costophrenic and cardiophrenic sinuses

B In lateral views of the chest it is important to observe 1) Position of the cardiac shadow in relation to the anterior chest wall (2) Position of the trachea and its clarity (3) Costophrenic angles both anterior and posterior (4) Size and demarcation of the superimposed hilus shadows of both lungs including the pulmonary trunks (5) Presence or absence of interlobar fissure shadows (6) Position and character of the shadow of the sternum (7) Lordosis or kyphosis of the thoracic spine (8) Presence or absence of areas of density or increased radiability with attention to the features of such an area listed in the preceding paragraph

C Similar observations should be made in other views

VASCULAR PATTERNS OF THE LUNG IN CONGENITA HEART DISEASE Increased or decreased flow of bloo through the lungs has a profound effect on the shadows of the pulmonary arteries Pulmonic stenosis whether isolated or associ ated with other defects as in tetralogy of Fallot produces a extreme diminution in the size of the blood vessels In som cases the pulmonary trunk or even one of its major branches may be enlarged as a result of post stenotic dilatation but th peripheral vessels will be obliterated to such a degree as to mak the lung fields extraordinarily clear [This appearance must b distinguished from that seen in simple emphysema in which th blood vessels are spread farther apart] In certain cases of pul monic stenosis the bronchial vessels dilate greatly and may b observed as somewhat straight linear shadows of much small diameter than those of the pulmonary artery On the contrar an increased flow of blood through the lungs as occurs in intra cardiac or extracardiac arteriovenous shunts causes a great in crease in the size of the vascular trunks This affects the larg vessels as well as the smaller ones Evidence as to the nature o congenital heart disease can thus be obtained from a study of th pulmonary arteries Other conditions in which the flow of bloo through the lungs is affected will likewise produce changes in th vascular pattern

Fig 34-1 —Interatrial septal defect *a* pulmonary trunk markedly dilated *b* left pulmonary artery partly overshadowe by pulmonary trunk *c* right pulmonary artery greatly enlarged *d* peripheral arteries greatly dilated Such findings are charac teristic of a left to right shunt

Fig 34-2 —Isolated pulmonic stenosis *a* post stenotic dilata tion of the pulmonary trunk *b* dilation of left pulmonary arter *c* right pulmonary artery very small The peripheral pulmonar vessels are markedly diminished in size so that the lung fields are unusually clear A few faint linear shadows can be made out most likely representing dilated bronchial arteries

34-1

34 2

PULMONARY EDEMA After pulmonary con[illegible] develops pulmonary edema may ensue although it does [illegible] necessarily follow congestive failure and may occur acutely independently of congestion Early in the course of p[illegible] edema a finely mottled diffuse almost miliary process ca[n be] made out In time the process becomes somewhat more strea[ky] and finally may assume a homogeneous form

Fig 35 —Pulmonary edema early stage case of heart fail[ure] A diffuse rather uniform process with however much [illegible] change at the periphery than in the medial portions of the [lungs] is quite characteristic The distinction between congestion [and] edema is shown In many areas linear shadows indicative [of] dilated veins are present in other areas there is a more ho[mo]geneous mottled appearance which results from the exudation [of] serum into the alveoli

Fig 36 —Pulmonary edema postoperative from overloa[ding] of the circulation In many such cases possibly owing in [part to] the patient's position the edema becomes somewhat loca[lized] giving an appearance of consolidation (*a*) although this is [dif]fuse edema of the left lung There is evidence of fluid in the ri[ght] pleural cavity as illustrated by the shadow of the interlobar fi[s]sure (*b*) Some edema of the right lung is also present No[te] however the tendency toward good aeration of the bases of th[e] lungs and at the periphery especially on the right

Fig 37 —Pulmonary edema postoperative in the upper lobe[s] Owing to the position of the patient the edema here appears [in] the upper lobes Note the streaked shadows interspersed wi[th] homogeneous densities

Fig 38 —Pulmonary edema from renal disease simulating infarcts and consolidation *a* local area of edema in the right upper lobe *b* local area of edema in the right middle lobe *c* aeration of the lung at the periphery

[Pulmonary edema *continued on page 96*]

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36

37

38

Fig 39A—Pulmonary edema from severe heart failure resul-ing from combined valvular disease postero-anterior view N the homogeneous diffuse density in the medial portions of th lungs At the periphery (*a*) however the lungs appear relativel clear and contain large quantities of air That this is not due en tirely to the position is illustrated by the lateral view (Fig 39B The relative radiability of the lung at the periphery is characte istic of pulmonary edema and helps in differentiation from oth conditions When the edema is homogeneous symmetrical a widespread diagnosis is not difficult When it is localized as Figure 38 the distinction from infarct or pneumonia may b impossible

Fig 39B—Same case lateral view Air is present both a teriorly and posteriorly as well as laterally In the medial a central portions of the lung the density appears almost soli which is typical of severe pulmonary edema in the last stag

39A

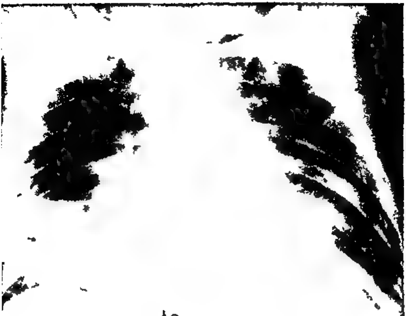
PULMONARY INFARCTS Roentgen examination discloses most pulmonary infarcts with a fair degree of certainty. It is sometimes difficult to distinguish them from pneumonia, and careful attention must be given to the history, the rapidity with which pleural effusion occurs and other factors such as enlargement of the heart which may cause pulmonary infarcts, in order to make the diagnosis. Many infarcts have a sharply angular shape, but when seen on end they may have a round or conical appearance. Some infarcts leave a permanent scar which can readily be made out in the roentgenogram; others disappear completely. [The infarct may be demonstrated within a relatively short time, perhaps 12 hours, after the onset of symptoms.]

Embolism may occur without infarction if the bronchial artery is not involved. In such cases there is seen an area of increased radiability owing to diminution in the amount of blood in the segment of lung supplied by the occluded artery.

Fig. 40A.—Massive infarct in the right middle lobe in a patient with cardiac failure from hypertension. September 29. Note the sharply delineated straight upper border of the density (a), indicating the position of the interlobar fissure between the middle and upper lobes. The heart is greatly enlarged. There is pulmonary congestion.

Fig. 40B.—Same case. November 3. Note the change in the appearance of the infarct (*a*) which has now become almost a linear shadow; this is often the end result of an infarct. A new infarct (*b*) which was not present on the previous examination has appeared. Pulmonary congestion, especially on the left side, is even more striking.

[*Pulmonary infarcts continued on page 100*]



40 A

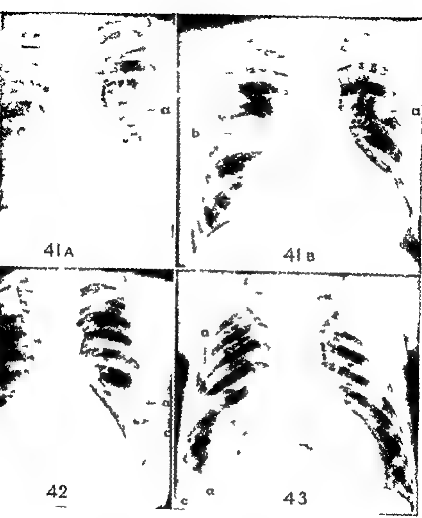
40 B

Fig 41*A*—Pulmonary infarcts in a patient who had had m attacks of coronary thrombosis roentgenogram 12 hours a onset of symptoms The shadow of the infarct (*a*) in the lu is characteristic of the earliest stages The hazy border and l of extreme density are typical in this early period before t infarct is well demarcated from the remainder of the lu Some pulmonary congestion can be made out

Fig 41*B*—Same case 18 days later The original infarct (a has become much smaller and much more sharply demarca and appears round because the cone-shaped process is show cut in transverse section Another infarct (*b*) not present wh the previous roentgenogram was made is in an early stage

Fig 42—Multiple pulmonary infarcts in a patient w pylephlebitis The infarcts (*a*) have a somewhat nodular appe ance and are fairly well demarcated from the rest of the lu The one at the right base just above the diaphragm near t cardiophrenic angle is a little fresher than the others and th fore less sharply defined Note the obliteration of the cos phrenic sinus (*c*) on the left and the somewhat similar oblit tion on the right Such changes denote the presence of fluid the pleural cavity and probably some diaphragmatic adhesi which occur very early in the course of pulmonary infar

Fig 43—Multiple pulmonary infarcts in a patient w cardiac failure from hypertension Infarctions (*a*) are pr in the right middle and lower lobes Obliteration of the ri costophrenic angle (*c*) indicates the presence of fluid in t early stages of the pulmonary infarct The rapid appearance o a pleural reaction after the onset of infarction is helpful in di tinguishing it from pneumonia


41A
41B
42
43

ARTERIOVENOUS FISTULA AND HEMANGIOMA OF LUNG   Congenital communications between the and the veins of the lungs may be part of a generalized, or localized to either one or both lungs. The roentgen so characteristic that in most cases the diagnosis should be parent from the ordinary postero-anterior and lateral views use of the Valsalva maneuver a diminution in the size of shadow may be produced with the Mueller procedure an largement occurs. Such findings are diagnostic. Planigrams extremely useful since sectional films made at different l will reveal the vascular character of the shadow. If plani are made with different degrees of intra-alveolar pressure diagnosis is more readily established. Angiography with medium will clinch the diagnosis but in most cases is unn sary.

Fig. 43-1A.—Arteriovenous fistulas of lungs, multiple; poster-anterior view. The lesion at the right base is particularly we shown but there are several fistulas on the left side which a less evident. a, aneurysmal sac; b, large vessels leading to sac; c, shadows of smaller aneurysms involving the left lung. The vascular trunks (b) leading into the sac (a) indicate th nature of the process.

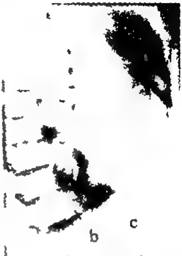
Fig. 43-1B.—Same case, lateral view. a, arteriovenous fistul in the right lower lobe; b, vessels leading to it; c, multiple fistula elsewhere in the lungs.

Fig. 43-2A.—Arteriovenous fistula, right lung, very large. The irregular, somewhat lobulated character of the shadow is typical. The structure is characteristic of vessels leading into an aneurys mal sac.

Fig. 43-2B.—Same case, body section roentgenogram showing the mass and the vascular character of the shadow. This was made with low intra-alveolar pressure (Mueller). Note the enormous size of the blood vessels in the mass, especially the one designated b. Compare with same vessel in Figure 43-2C.

Fig. 43-2C.—Same case, planigram made at the same level as in Figure 43-2B but with increased intra-alveolar pressure (Valsalva). Note the marked diminution in size of the vessels par ticularly the one designated b.

43 1A



43 1B

43 2B

43 2A

43 2C

PNEUMONIA In acute pulmonary conditions partic larly pneumonia roentgen examination is invaluable in mak the following determinations

1 Whether there is a lesion in the parenchyma of the This is particularly important for early diagnosis of pneum so that specific therapy can be instituted Bacterial p m can be diagnosed a few hours after onset of symptoms In ot types of pneumonia the x ray changes may appear less rap but generally speaking in the earliest stage are more diagnos than the physical findings and may be crucial in differentiat between a bronchial lesion and one in the lung parenchyma.

In all patients especially children with symptoms of acute abdominal condition such as acute appendicitis roentg examination should be done as routine to exclude pne since it may mimic the abdominal condition

2 Differentiation of the type of disease. Abscess infa acute tuberculosis and the various pneumonias can often distinguished by x ray study

3 Distribution and localization of the pneumonic process

4 Progression or regression of the disease

5 Process of resolution X ray study shows whether it normal or slower than normal and whether residual process such as unresolved pneumonitis abscess or pleural chan remain

6 Complications such as pleurisy with effusion abscess at atelectasis

The roentgen findings in pneumonia depend on the replac ment of air by denser tissue such as exudate fibrin fluid a blood The lobar types of bacterial pneumonia usually begin a peripheral, rarely as central lesions It is important to mak films in two positions to determine this Usually the density triangular with its base at the periphery whether medial la eral anterior or posterior and its apex at the hilus

As lobar pneumonia develops the distribution in the variou lobes is clearly made out Anteroposterior and lateral vie show the exact localization Lesions of the atypical pneumo ia are less clearly limited to the lobes they may be complet l

bular in distribution giving a patchy appearance on the film Pneumonia arising behind the heart increases the density of e cardiac shadow One must remember that areas of the lung low the domes of the diaphragms may be involved

In lobar pneumonia sometimes only a portion of the lobe is volved In bronchopneumonia and the atypical pneumonias it common to find only small patches distributed irregularly roughout the lung fields

The influenzal type of bronchopneumonia may show local ed lesions Such consolidations in the subclavicular portions of e lung resemble early tuberculosis Rapid resolution often ves the only clue to the disease

Certain specific types of pneumonia should be particularly oted Rarely a staphylococcic pneumonia occurs in which rge cavities resembling abscesses develop rather rapidly after nset Tularemic pneumonia usually causes rather extensive ensities in the lung and rapid and severe pleural involvement n some cases multiple nodular areas also occur The type of neumonia often called eosinophilic (Loffler s syndrome) auses multiple fleeting patches of density probably represent ng local edematous areas in the lung and characterized by their hange from day to day

Repeated examinations give an excellent picture of the prog ess of pneumonia In ordinary pneumonia there is no cardiac isplacement However atelectasis is often present at the outset or appears as a complication with mediastinal shifting Abscess, een as an area of rarefaction with a fluid level may develop

The appearance during the stage of resolution is often con using because of irregular, feathery, ragged looking shadows which may alternate with areas of rarefaction Repeated exam ination in a few days however indicates the nature of the process With failure of resolution there is a tendency to mul tiple irregular areas of density which may eventuate in con tracted lung

Changes in the pleural shadows which indicate early empyema interlobar effusions and pleural thickening may also be observed

PNEUMONIA EARLY STAGE The onset of pneumonia and its development progression and regression the development of complications and the localization and the pneumonic process can be delineated effectively in roentgenogram. The onset of typical lobar pneumonia is readily apparent and demonstrable within 12 hours after first appearance of symptoms and often much earlier. At the consolidation may take the form of a peripheral with its base at the lateral pleura its apex medially. In cases the area of density is medial and may appear to be central. Central pneumonia has often been diagnosed from anterior views. Lateral views however indicate that the consolidation is posteromedial but still peripheral. Such lateral views may be particularly helpful in localizing a lesion to exact portion of the lung in which it has arisen and in determining its extent. In some instances the lateral view is the best means of observing the early stages of pneumonia.

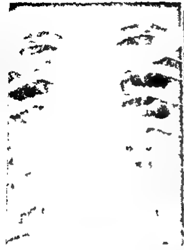
Fig. 44A.—Lobar pneumonia early stage postero-anterior view. Because of its superimposition the consolidation (*a*) appears to be in the root of the right lung. Actually it is medial and posterior.

Fig. 44B.—Same case lateral view. This demonstrates the posterior location of the consolidation (*a*). It is in the apex of the right lower lobe which usually has a medial position. The density is somewhat triangular with its base at the periphery of the lung posteriorly and its apex approaching the hilus.

Fig. 45A.—Lobar pneumonia apparently central in origin in a child relatively early postero-anterior view. The consolidation (*a*) appears to be in the root of the left lung.

Fig. 45B.—Same case lateral view. The consolidation (*a*) actually is posterior and medial involving the apex of the lower lobe. It has a characteristic triangular shape the border corresponding to the position of the major interlobar fissure and the lower border fading out into more normal lung beneath. The base of the triangle is posterior and the apex the root of the lung.

[Pneumonia Early stage *continued on page 108*]



44 A

45 A

44 B

45 B

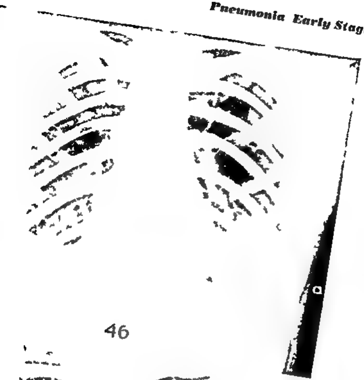
The roentgen appearances of the bacterial pneumonias a[nd] the atypical or virus types differ The roentgen findings in t[he] latter appear later and the shadow is often more extensive th[an] the symptoms suggest Usually the lesions are not well demarc[ated] or homogeneous In lobar or bacterial pneumonia the x [ray] changes appear early but are often less extensive than the p[a]tient s symptoms seem to indicate

Fig 46 – Lobar pneumonia 18 hours after onset There is consolidation (*a*) in the left lower lobe apparently beginn[ing at] the periphery of the lung near the diaphragm and medially This presents the picture of a peripheral triangle the base lateral and inferior and the apex extending to root of the lung The consolidation is uniform and h[omogeneous] at this stage

Fig 47 – Atypical pneumonia 36 hours after onset The [ap]pearance is that of a streaked infiltration (*a*) along the [bron]chovascular trunks with a somewhat mottled appearance [In] later stages there may be a more dense uniform consol[idation] Note the contrast between the degree of density and the [char]acter of the shadow in the bacterial pneumonia (Fig 46) [and] those in the atypical variety here shown In some cases of bac[]terial pneumonia an appearance similar to that seen here [de]velops within a few hours after onset but rapidly becomes mor[e] dense and homogeneous

The consolidation of pneumonia can readily be demonstr[ated] at an early stage Both lateral and anteroposterior views [are] desirable for this although even bedside films with the pa[tient] supine may be sufficient to exhibit minimal degrees of consol[ida]tion In the pneumococcus type of lobar pneumonias three to [] hours may be required before the consolidation is clearly app[ar]ent in the roentgenogram

[Pneumonia Early stage *continued on page 110*]



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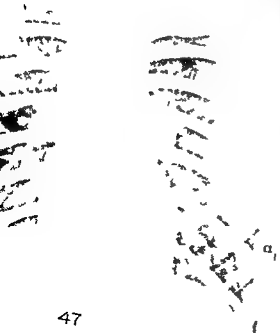

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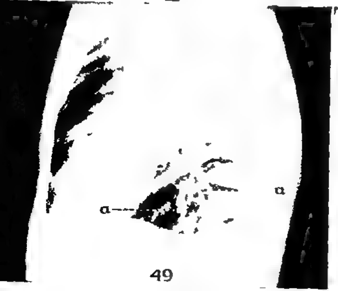
Fig. 48A.—Lobar bacterial pneumonia early stage and progression postero-anterior view supine position 12 hours after onset. Only the right side of the thorax is shown. There is a angular area of consolidation (*a*) with the base on the diaphragm. The density seems to represent simply an increase in the broncho-vascular markings but its homogeneity extent and typical triangular shape identify it as early evidence of lobar pneumonia.

Fig. 48B.—Same case approximately one week later. The consolidation (*a*) has extended to involve the whole cardiophrenic angle and upward to the root of the lung. Note the sharp demarcation of the consolidation the preservation of the triangular shape and the marked homogeneity of the process. The pneumonia was confined to an anomalous right inferior accessory

Fig. 49.—Lobar bacterial pneumonia in a child 25 hours after onset. Lateral view. Because this child was hospitalized for other reasons the time of onset could be stated exactly the film was made soon after the first symptom appeared. The early changes are shown at *a*. Note the triangular density with the base posterior and inferior and the apex extending up to the hilus of the lung. The shadow is not homogeneous as in the later stages of pneumonia but instead presents a streaked, mottled appearance because areas of aerated lung remain. This is the typical appearance of a pneumonic consolidation seen at the earliest possible time after onset.

48A

48B



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LOBAR (BACTERIAL) PNEUMONIA The degr extent and anatomic distribution of a consolidation may be ac curately determined by roentgen examination if various positi are used The lobes involved and any atypical arrangements, su as may result from anomalous lobes unusual positions of t pleura or incomplete consolidation are also visualized

Fig 50 – Right upper lobar pneumonia pneumococcus typ anteroposterior view The dense homogeneous shadow (*a*) sharply demarcated below at the interlobar fissure and fades o somewhat above A typical interlobar fissure (*b*) demarcates anomalous azygos lobe from the upper lobe the consoli stops abruptly at this point A consolidation may occur in azygos lobe without involving the upper lobe Note the geneity and sharply defined character of the shadow of pneumonia

Fig 51 – Lobar pneumonia right lower lobe anteroposter view There is a dense triangular shadow at the right base (with its base at the periphery and its apex directed toward t lung root The consolidation is sharply demarcated medially f a well aerated anomalous inferior accessory lobe (*b*)

Fig 52*A* – Lobar pneumonia pneumococcus type right mi dle lobe anteroposterior view supine position There is a dens homogeneous shadow well distributed in the shape of the ri middle lobe It is sharply demarcated above (*b*) because of th position of the horizontal interlobar fissure which runs straig across The density fades out below (*c*) because the middle lob becomes thinner as it extends downward and the aerated low lobe can then be superimposed Note the area of lessened dens between the consolidation and the cardiac shadow In some in stances the shadow of a middle lobe consolidation blends w that of the heart

Fig 52*B* – Same case lateral view The middle lobe is clearl outlined between *b* and *c* The shadow of the consolidation its apex at the junction of the horizontal and oblique interlob fissures The anterior portion of the lobe is still aerated Th cardiac shadow can be made out behind the consolidation be hind this is the aerated lower lobe

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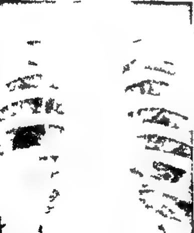

52A

52B

After consolidations of the lung are fairly well estab[lished] their extent and distribution may be accurately determine[d] postero anterior or anteroposterior and lateral views The u[se] these views is often highly important for determining the [pro]gression of pneumonia and its extent Diagnosis based on th[ese] methods is much more accurate than that based on the phy[sical] findings and causes the patient less discomfort

Fig 53A —Lobar pneumonia pneumococcus type well es[tab]lished anteroposterior view supine position Consolidations shown at *a* *b* and *c* all three lobes on the right side bei[ng in]volved It is not possible from the anteroposterior view al[one] however to distinguish one from the other Note how the lo[wer] consolidation (*c*) overlaps the right border of the heart and [in]creases its density The density of the cardiac shadow on the [left] side is normal (*d*)

Fig 53B —Same case right lateral view The distribution [of] the consolidations is clearly visualized in this view *a* pr[...] in the right upper lobe demarcated posteriorly by the obl[ique] fissure and merging into the middle lobe anteriorly The up[per] and anterior portions of the right upper lobe are not consolid[ated] as shown also in the anteroposterior view *b* consolidation in [the] middle lobe which is anterior It is sharply demarcated below [by] the oblique fissure and increases the density of the heart in [this] view The normal density of the cardiac shadow is sh[own] posteriorly and below (*d*) *c* consolidation in the right lo[wer] lobe which has a roughly triangular shape its base being p[oste]rior its apex anterior In this manner the distribution of lo[bar] pneumonia in three lobes on the right side can be clearly [de]termined

[Lobar pneumonia *continued on page 116*]

53 A

53 B

Fig 54A—Lobar pneumonia in a child 18 hours after on anteroposterior view There is a rounded homogeneous dens (*a*) in the right lower lung characteristic of an early consoli tion

Fig 54B—Lateral view made at the same time The dation (*a*) is seen to be truly central within the right lower l Such a distribution is occasionally seen in the early per *b* a density which is the result of superimposition of soft ti shadows occasioned by pulling the arms upward

Fig 54C—Same case four days later A ribbon like ar density (*c*) is seen at the periphery and the whole hemithe is cloudy This is typical of fluid in the pleural cavity Such p pneumonic empyemas are not uncommon in children

The exact distribution of pulmonary consolidations can be determined unless heavy penetrating exposures are made that way the shadow of pneumonia can be differentiated from shadows of the heart and diaphragms

Fig 55A—Lobar pneumonia right middle and lower postero anterior view upright position normal exposure fuse density of the pneumonia which merges into the shadow the heart and diaphragm obscuring them The costophrenic s is not seen so the possibility of pleural effusion cannot be cluded

Fig 55B—Anteroposterior view heavy exposure made at same time a consolidation in the right lung showing less den *d* shadow of the diaphragm now distinct from that of the pn monia Note the fairly clear costophrenic sinus ruling out pleu effusion *e* density of the right side of the heart greatly increas in comparison with that of the normal left side (*f*) on superimposition of the consolidated lung It can therefore concluded that the lower lobe is involved since the middle l does not overlap the heart *The flat* sharply defined super border of the density indicates consolidation of the middle lol Thus the diagnosis of right middle and lower lobe pneumon established without study of a lateral view Note the elevat right diaphragm indicating presence of associated atelecta

54A

54B

54C

55A

55B

CARDIAC DENSITY IN PNEUMONIA In any st of the chest the density of the cardiac shadow should be cl observed Normally both sides of the heart exhibit approxim the same degree of opacity The density is increased in the ce tral portion of the cardiac shadow where it is overlapped by spine, descending aorta and other mediastinal structures Le lying in front of or behind the heart and overlapping the ca shadow contribute to its density a comparison of the two of the heart therefore often reveals a process in the lun pleura which would not otherwise be observed This is true p ticularly in pneumonia and also in pleurisy with effusion, tu and other abnormalities Especially in the left lower lobe, t earliest evidence of a consolidation often consists only in a in cardiac density Obviously in lateral views such a co tion might be seen lying posterior to the heart as in Figure but when the patient is acutely ill a lateral view may not obtainable so the cardiac density must be carefully scrut

Fig 56 —Lobar pneumonia left lower lobe early stage a treme density of cardiac shadow left of the spine *b* m shadow of consolidation beyond cardiac border *c* nor density of right side of heart Comparison of the two sides the heart reveals that on the left a summation of the shad of the heart and of the consolidated lung has changed the d Diagnosis of pneumonia might be missed if the cardiac sh were not observed

Fig 57 —Lobar pneumonia left base early stage *a* incr density of cardiac shadow well localized to region of *b* consolidation extending into the periphery *c* normal d of right side of heart *d* normal density of central shadow gion of spine and descending aorta Note the differen density of the inferior lateral portion of the left heart a the remaining cardiac shadow The density of the consoli (*a*) is roughly equivalent to that of the spine and aorta Overexposure is necessary to bring out such density diff

ATYPICAL PNEUMONIA The atypical pneumonia of unknown etiology, commonly thought to be due to a virus, gives a picture distinctly different from that of lobar pneumonia. The changes are much less sharply defined, appear somewhat later in the course and are much more variable in their ...

A number of good examples of the varying phases of ... pneumonia are illustrated here. In none of the cases could specific organisms be obtained from the sputum; the reaction to therapy and the clinical course established clearly the diagnosis of atypical pneumonia of unknown etiology.

Fig 58.—Atypical pneumonia, early stage, anteroposterior view. *a*, area of mottled irregular, poorly defined density in medial portion of the right lung. A tendency to a medial ... with extension up toward the root of the lung, lack of sharp definition and homogeneity are characteristic of this type of l... Note density of the cardiac shadow (*c*), which is greater than that to the left of the spine, indicating lower lobe involvement.

Fig 59.—Atypical pneumonia of unknown etiology, posterior view. Diffuse mottled nodular densities involve almost the entire lung. The appearance closely resembles that of acute bronchiolitis, but the changes are more localized, involving only the right lung, and there is an area of coalescence in the middle portion. This type is not unusual.

Fig 60.—Atypical pneumonia, anteroposterior view. *a*, sharp upper border of fairly dense consolidation indicating middle lobe involvement. *b*, extension of density above interlobar fissure indicating extension into apex of the lower lobe. The shadow is more uniform and dense here. The extension beyond the lobar boundary is characteristic. Note the equality of density of the right (*c*) and left (*d*) sides of the heart.

Fig 61.—Atypical pneumonia with atelectasis, same case as that in Figure 59, at another stage. *a*, consolidation in lung, irregular, not sharply defined, nonhomogeneous. *c*, right border of heart displaced toward the affected side. *d*, elevated right diaphragm. *e*, normal position of left diaphragm. Atelectasis is more common with atypical than with bacterial pneumonia. It is demonstrated here by displacement of heart and diaphragm.

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One of the striking features of atypical pneumonia is presence of extensive x ray changes while physical findings a almost entirely lacking This discrepancy may have importa diagnostic significance It is in sharp contrast with lobar pe monia in which the physical findings are more in keeping w the roentgen changes

Fig 62A—Atypical pneumonia 24 hours after onset late view supine position a roughly triangular area of consolidati resembling closely that seen in early lobar pneumonia No phy cal signs were present not even suppression of breathing b el vated right diaphragm indicating some atelectasis The consolid tion extends down over the diaphragmatic shadow because its lateral position c normal level of left diaphragm

Fig 62B—Same case 84 hours later The consolidation (a has extended considerably and is much more homogeneous a dense The diaphragm (b) is more elevated than in the earl film and now overlaps the cardiac shadow the posterior bor of which is at d Extension of atelectasis is apparent The l diaphragm (c) is at a much lower level Throughout the ch acteristic course of atypical pneumonia the absence of phys signs despite the extensive x ray changes was notable

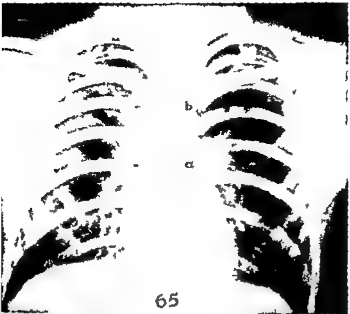
Fig 63—Atypical pneumonia postero anterior view upri position An irregular, mottled area of consolidation in the l upper lobe with multiple nodules (a) illustrates another type atypical pneumonia Irregular distribution of the consolidati and character of their densities indicate that this is not lob pneumonia Bronchopneumonia secondary to influenza or oth infections may give exactly the same findings

Fig 64—Lobar consolidation in a case of atypical pneumon seven days after onset The right upper lobe is densely consol dated almost homogeneous At this time careful physical ex amination revealed few changes despite the extent and densi of the consolidation In occasional cases of atypical pneumon the consolidation closely resembles that of lobar pneumonia, bu the absence of physical signs is helpful in differentiation

BRONCHOPNEUMONIA IN CHILDHOOD Many the cases once designated as bronchopneumonia are now more correctly classified in the group of atypical pneumonias of unknown etiology or as more specific types of lesions Occasionally however and especially in children bronchopneumonia which does not run the typical course of virus pneumonia is encountered It is important to observe that such pneumonia as well as the lobar type when involving the right lower lobe may simulate acute appendicitis In all cases of suspected acute appendicitis especially in children a routine film of the chest should always be made to exclude the possibility that pneumonia is the cause of the symptoms

Fig 65—Bronchopneumonia simulating acute appendicitis A child with classic symptoms and signs of acute appendicitis was brought in for surgery The temperature was rather high but there were no other symptoms or signs of a lesion in the chest Owing to faulty interpretation of the roentgenogram he was operated on and a normal appendix removed The usual course of bronchopneumonia followed and he recovered despite the surgery *a* consolidation around the root of the right lung probably in the apex of the lower lobe *b* another area of consolidation in the right upper lobe

Fig 66—Bronchopneumonia diffuse secondary to measles In the acute exanthematous diseases of childhood pertussis and other conditions bronchopneumonia is not an uncommon complication In all probability the bronchopneumonia in many of these cases is due to a virus infection but the findings may differ somewhat from those of ordinary atypical pneumonia The characteristic features shown here are multiple nodular densities throughout large portions of both lungs The distribution is irregular and there is no definite lobar consolidation The nodules are large and the roots of the lung appear to be engorged A similar picture may occur with atypical pneumonia so that it may be difficult to distinguish the two conditions



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ACUTE BRONCHIOLITIS A type of bronchopneumonia, probably virus in origin and called bronchiolitis or capillary pneumonia, often produces a clinical picture simulating miliary tuberculosis. Roentgenologically it may resemble miliary tuberculosis, miliary carcinomatous metastases and other lesions. It may be recognized by the rapid changes in the roentgen findings observed on repeated examinations.

Fig 67—Capillary pneumonia. The patient was extremely ill with severe dyspnea, tachypnea, cyanosis and high fever. There is diffuse uniform mottling of both lungs from apex to base. The nodules are somewhat coarser than those usually seen in miliary tuberculosis. The shadows remain for a much longer period than in ordinary pneumonia but tend to disappear eventually.

Fig 68—Subacute bronchiolitis. The patient had had a carcinoma of the breast removed about six months previously. When this roentgenogram was made she had acute respiratory symptoms but little fever. The demonstration of the numerous discrete shotlike nodules throughout both lungs led to the conclusion that she was suffering from miliary carcinomatous metastases. Within two months the nodules disappeared completely. A careful review of the history and symptomatology indicates that this was a case of subacute bronchiolitis which, however, closely simulated a miliary tuberculosis or miliary carcinomatous metastases. In such instances the only way to establish the correct diagnosis is to make repeated examinations over a period of several weeks or even a month.

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PNEUMONIA MISCELLANEOUS TYPES Ir ous types of acute pulmonary infections occur which are dis from ordinary lobar and atypical pneumonia

Fig 69 — Aspiration pneumonia postoperative Note the r tively medial position of the density its lack of homogeneity the mottled character of the process It appears to extend toward the periphery from the medial portions of the lungs

Fig 70 — Aspiration of hemorrhage into the lung The pro closely resembles that of aspiration pneumonia In this cas was due to a hemorrhage in the trachea from which blood aspirated into the bronchi causing the areas of consolidation in the medial portions of the lung The densities are actually to blood within the bronchi some atelectasis from obstructio the bronchi and some aspiration of blood into the alveoli

PNEUMONIA IN INFANTS Pneumonias occur in infants are of particular interest because the x ray changes quite different from those of pneumonia in adults

Fig 71 — Pneumonia secondary to thrush in a young in a medial density closely resembling pulmonary edema b p ipheral emphysema commonly found with acute pu lesions in infants

Fig 72 — Laryngotracheobronchitis in an infant There characteristic emphysema with increase in markings Both l and generalized emphysema and atelectasis occur a atel of right upper lobe which is shrunken with increase in de and a sharp lower border

Fig 73A — Laryngotracheobronchitis in an infant post anterior view Note extreme emphysema with conspicuous crease in the bronchovascular markings c low diaphragms fr the over aerated lungs

Fig 73B — Same case lateral view There are excessive dis tion of the lungs anterior to the heart (*b*) and increase in t markings throughout both lungs


69


70


71


72


73A


73B

CHRONIC INTERSTITIAL PNEUMONITIS A diffuse infiltrative process occurring in both lungs and persisting over long periods often for years may give a fairly characteristic roentgen picture

Fig 74 —Diffuse streaked and mottled densities through both lungs are characterized by their fibrotic appearance. The diaphragms are often elevated owing to lack of aeration of the lungs The root shadows are increased

TULAREMIC PNEUMONIA With tularemia there may be pneumonia and pleurisy which sometimes present a sufficiently characteristic picture to suggest the diagnosis The lesions are usually bilateral and there is a remarkably rapid and severe pleural reaction

Fig 75 —Bilateral involvement, with pleural effusion already present on the left in addition to consolidation at the base. On the right are some involvement of the interlobar fissure peripherally and a diffuse infiltrative process at the right base. Another area of consolidation is present in the left upper lobe lateral to the lung root

EOSINOPHILIC PNEUMONIA A type of acute process occurring in the lungs is characterized by striking eosinophilia and fleeting irregular mottled densities in almost any portion of the lungs A striking feature is the fleeting nature of the consolidations which resolve in one area and recur in another

Fig 76A —Eosinophilic pneumonia with acute pulmonary symptoms and eosinophilia postero anterior view upright position Note the mottled nodular and streaked densities in the right upper lobe enlarged root shadows on both sides and diffuse rather uniform density in the left upper lobe The appearance is consistent with atypical pneumonia of rather unusual distribution

Fig 76B —Same case three days later There are striking resolution of the process in the left upper lobe and some changes with extension deeper into the left lung Such variations on repeated examinations are characteristic (Courtesy of Dr Ernest Mariette Glen Lake Sanatorium Oak Terrace Minn)


74
76 A
75
76 B

PNEUMONIA RESOLUTION For the first 24 hr after a crisis or beginning lysis in pneumonia relatively few changes take place in the roentgenogram Then some irregular rarefactions begin to appear in the areas of density with numerous feathery mottled densities remaining These rarefactions are often mistaken for cavitation when in fact they represent somewhat emphysematous well aerated lung tissue especially when seen in contrast with the surrounding exudate-filled alveoli In the average case the process continues for some time until almost complete resolution has taken place In cases of unresolved pneumonia repeated examinations show residua of the process

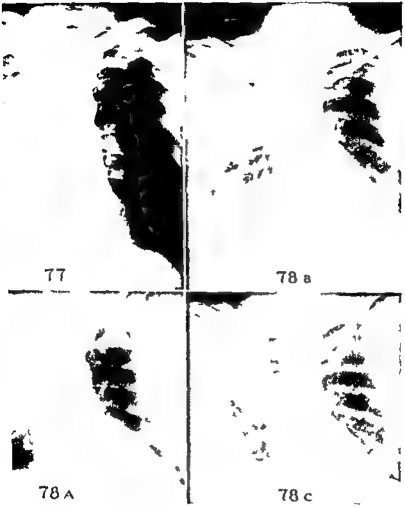
Fig 77 —Lobar pneumonia 24 hours after onset of crisis Consolidation was present in the entire right lung In this film is shown the beginning of resolution characterized by the findings previously described

Fig 78A —Lobar pneumonia right upper lobe 10 days after onset postero-anterior view Note the characteristic diffuse homogeneous density well confined to the right upper lobe

Fig 78B —Same case six weeks later postero-anterior view Note the diffuse infiltrative process with numerous areas of rarefaction suggesting resolution In view of the time which has elapsed resolution is quite incomplete

Fig 78C —Same case five weeks later three months after onset of the acute illness Diffuse areas of fibrosis and nodular infiltration are still present in the right upper and to a lesser degree the right middle and lower lobes This is a characteristic picture of pneumonia resolving very slowly over a long period It resembles nonspecific fibrosis of the lung and may be difficult to distinguish from tuberculosis if the history and previous x-ray findings are not known

It is to be noted that atypical pneumonia tends to resolve more slowly than pneumonia of bacterial origin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78 B
78 A
78 C

ATELECTASIS Atelectasis is exceedingly important because it accompanies many pathologic conditions and presents diagnostic roentgenologic findings. The changes in the lung result essentially from either obstruction of the bronchi or compression of the lung from extrinsic sources. Compressive atelectasis is of relatively little importance roentgenologically since the major process is usually obvious and is diagnosed on the basis of its own signs. Atelectasis from bronchial obstruction causes striking changes. Whether the stenosis be due to a foreign body, tumor, mucus plug or inflammatory constriction, the x-ray signs may be similar. The occlusion may be in a large bronchus or many smaller bronchi. Regardless of the nature of the obstructive mechanism, the findings depend on the location of the obstruction, its extent and the length of time it has been present.

In general, atelectasis produces a density of one or more lobules or lobes of the lung resembling pneumonia in its general contours. It may have a highly diffuse mottled appearance throughout the lung when many small bronchi are involved, as, for example, in bronchial asthma and occasionally in massive postoperative atelectasis, either of which may result from the accumulation of mucus in the smaller bronchi.

The most striking feature is the displacement of the trachea, heart and mediastinum toward the side of the lesion, more during inspiration than expiration. The diaphragm on the side of the lesion is elevated. It is not always possible to demonstrate this latter change when atelectasis involves a lower lobe, although an overexposed film often makes the position of the diaphragm clear. Typically, in atelectasis the process is not quite as dense or as homogeneous as is usual in pneumonia, although in some instances, because of retention of fluid in the bronchi and exudation of fluid into the alveoli, the process closely resembles that of pneumonia.

With atelectasis the remaining portions of the lung are often emphysematous and show striking increase in radiability. This is particularly true of chronic atelectasis. In children the compensatory emphysema is conspicuous and distention of the other

bes may be so great as to militate against displacement of the mediastinum and diaphragm

The shadows produced by atelectasis disappear much more rapidly than is usual in pneumonia This is due to the fact that only simple re aeration is needed because there is relatively little exudate to be absorbed Occasionally alternate collapse and clearing occur depending on the nature of the obstructive mechanism

Atelectasis at the bases of the lungs may cause no x ray changes since these portions may be covered by the diaphragms which are usually elevated This is particularly true in atelectasis following operations on the abdomen

During pneumonia a sudden displacement of the mediastinum toward the side of the lesion usually indicates the onset of atelectasis as a complication

Bronchiectasis occurs with the chronic atelectasis associated with long standing obstruction of the bronchus as with benign bronchial adenoma and long retained foreign bodies and with constrictions from an old inflammatory process The bronchiectasis may be manifested radiographically by areas of rarefaction in the diffuse area of increased density so that in some cases of atelectasis the density of the lung is not as marked as might be expected

In some instances there is striking displacement of the heart mediastinum and diaphragm without extreme density of the lung This is due to the fact that the air content of the lung has been reduced without a corresponding increase in the fluid quantity In other cases however the atelectatic lobe is hidden behind the shadow of the heart or diaphragm and therefore is not clearly visible although the density is actually increased

Atelectasis may show a residuum in the form of platter like linear shadows which are the result of contraction of an atelectatic segment

Fig 79—Massive atelectasis 24 hours after appendectomy *a* diffuse characteristic density of right lung *b* displacement trachea toward involved lung The esophagus containing a tion tube is also displaced to the right *c* right border of heart displaced far to the right side *d* left border of the h projecting just to the left of the spine owing to marked d placement *e* elevated right diaphragm visible because aerated lung just above In many cases the diaphragm cannot seen because of the extreme density of the hemithorax.

This roentgenogram is entirely characteristic of postoperative massive atelectasis but a similar picture may be produced by bronchial foreign body or other type of high grade bron stenosis

Fig 80—Massive atelectasis left lung, postoperative B cause of the extreme density of the entire left lung the diaphra is not visible and its elevation cannot be demonstrated The p sition of the diaphragm can be revealed by administering c bonated water or barium sulfate to make the high position the stomach visible The heart is displaced well to the left, indicated by absence of the cardiac shadow to the right of t spine (*f*) The interspaces on the left side are reduced

Fig 81—Massive atelectasis following overdose of morph The findings are similar to those in Figure 79 except that more the lung is dense The extreme density is due probably to acc mulation of fluid in the alveoli and smaller bronchi rather th to actual collapse of the lung

Fig 82—Atelectasis right lower lobe after cholecystectomy Note that the major portion of the right lung appears to be re sonably well aerated The area of atelectatic lung lies behind t heart but is hidden by the cardiac shadow *b* displacement the trachea to the right *c* right border of the heart displace well over to the right *e* elevated right diaphragm The increase density of the right side of the heart (*g*) as compared with th of the left side (*h*) indicates the effect of the superimpose atelectatic lung

[Atelectasis Obstructive *continued on page 138*]

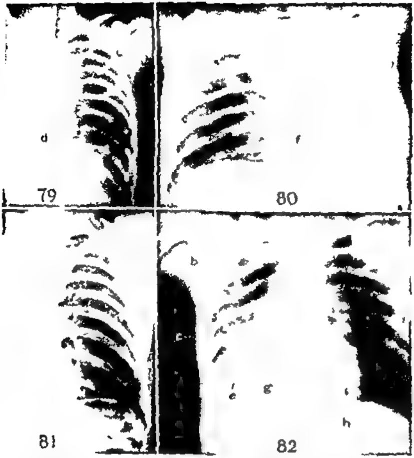
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Fig 83 – Congenital atelectasis The appearance differs ordinary atelectasis in that mediastinal displacement is treme Observation in a newborn establishes the diagnosis dense shadow in the right hemithorax is composed of the lapsed lung fluid in the alveoli and bronchi and the shadow the heart which lies completely within the right chest *b* displaced to the right *c* an area of rarefaction herniation of the emphysematous left lung into the right thorax

Fig 84 – Massive atelectasis from foreign body obstructing right main bronchus A bean had been aspirated 24 hours examination Note similarity of findings in Figure 83 *b* displaced to the right *c* herniation of emphysematous left into right hemithorax *d*, left border of heart indicating how it is displaced to the right side The entire right hemithorax completely dense

Fig 85A – Atelectasis of right middle lobe incident to inflammatory bronchial occlusion two weeks after onset lateral *a* atelectatic middle lobe There is a triangular area of much smaller than the normal middle lobe *c* stenosis of middle lobe bronchus disclosed by iodized oil Note the ward and anterior position of a portion of the right upper bronchus (*f*) owing to compensatory expansion of the Some iodized oil has extended into the alveoli of the right lobe (*g*) which is expanded forward to compensate for shrinkage of the middle lobe

Fig 85B – Same case 18 days later lateral view Resolution was spontaneous no doubt owing to extrusion of the obstructing mechanism from the right middle lobe bronchus The lobe expanded although not completely The fissures between middle and lower lobes (*h*) and between middle and upper lobes indicate the degree of expansion Density of the lobe (*a*) is increased only in the very anterior portions where it is superimposed on the cardiac shadow

83A

85A

84

85B

EMPHYSEMA AND BRONCHIAL ASTHMA The di- tention of the lungs which may result from partial obstruction a large bronchus or similar obstruction of smaller bronchi may have characteristic roentgen features Whether the emphyse- is the nonspecific type frequently seen in older individuals, t result of bronchial asthma or a more acute type such as occ with partially obstructing tumors and foreign bodies the ge- results from a roentgenologic point of view are the same l general also the compensatory emphysema which occurs in lung when the opposite lung is nonfunctioning and that wh occurs in one lobe when the contiguous lobe is atelectatic p duce much the same findings

The characteristic roentgen signs are depression of the di- phragms widening of the intercostal spaces and a general i crease in radiability of the involved lung The last is difficult determine comparison with the average normal for the parti- lar type of individual may help somewhat Generally speak the bronchovascular markings are increased in density but app to be farther apart than they are in the normal individual T root shadows also are increased in size and density Usually th central shadow of the mediastinum is rather long and narrow I lateral views the sternum is seen to bulge forward the radiab area anterior to the heart above and posterior to the heart be low is much larger than normal In some instances the lung i seen extending in front of the heart well down toward the di phragm The spine is often kyphotic

In such diseases as silicosis the emphysema may be wel localized in the outer portions of the lungs In cases of lung tumo localized emphysema may develop close to the site of obstruc tion

Accompanying the nonspecific type of emphysema there ma be large areas of increased radiability representing emphy sematous bullae Such pockets rarely contain fluid They are char acterized by a thin line of increased density surrounding the are of rarefaction Within the area the lung markings are almost in visible The localized character of the process distinguishes i from pneumothorax

In allergic asthma, although emphysema is outstanding ner signs may also be observed The bronchovascular markings e greatly increased owing to partial occlusion of the bronchi by cumulated mucus The root shadows are distinctly enlarged d secondary inflammatory processes may produce patchy areas density As a complication of asthma patchy areas of atelec sis are not uncommon and in some instances lobar atelectasis sults when the mucus plugs become so large as to obstruct the onchus completely

By bronchography the obstruction of the smaller bronchi haracteristic of asthma can be demonstrated The terminal por ons of the peripheral bronchi of the third and fourth order ave a snub nosed appearance with it is a lack of the arboriza on which commonly occurs when iodized oil is introduced into ie bronchi Although such obstruction may occur with other ronchial conditions it is far more common in and more charac ristic of asthma

In occasional cases of allergic asthma one lung is somewhat iore emphysematous than the opposite lung thus giving the ppearance of unilateral emphysema

Fluoroscopic examination as well as films made during inspi ation and expiration in the case of emphysema reveals most learly the relative absence of motion of the diaphragms during espiration In some cases especially those in which the partial *ronchial obstruction is relatively acute* there is a paradoxical hange in the size of the heart

It should be noted that emphysema and atelectasis may re ult from the same process This is discussed more fully in rela ion to the localized emphysemas from foreign bodies broncho-*tenosis and tumors*

Fig 86 —Pulmonary emphysema of unknown etiology the long narrow chest wide intercostal spaces and mark overaerated radiable lungs (a) Root shadows (b) are increased in size the pulmonary vessels usually being distended The major pulmonary trunk is usually enlarged arc of the pulmonary artery (c) being much longer dilated than normal—a manifestation of right heart enl secondary to emphysema Linear areas of atelectasis and t ing of the interlobar pleura (d) are common residua of areas of atelectasis which occur intermittently in such cases diaphragms (f) are extremely low the one on the left appear be inverted

Fig 87 —Pulmonary emphysema of unknown etiology l view Long standing emphysema produces marked enlarg of the thorax in its anteroposterior diameter Note kyphosis of thoracic spine and anterior bulging of the sternum A chara istic feature is enlargement of lung space which normally be front of the heart and aorta under the sternum (a)

Fig 88 —Pulmonary emphysema with chronic nontuberc lung fibrosis both upper lobes Extensive fibrotic infiltration the upper lobes with numerous areas of rarefaction int represents emphysematous blebs or areas of alveolar ec The rest of the lung fields is greatly distended and incre radiability Root shadows of both lungs (b) are elevated siderably owing to retraction of the fibrotic upper portion tachments of the extremely depressed diaphragms (f) to nl bony structures are seen

Fig 89 —Pulmonary emphysema bronchogram po anterior view a large pneumatoceles resulting from al ectasia In some cases such air pockets often called air v become very large with sharply defined borders owing to ginal atelectasis of the surrounding compressed lung c somewhat dilated and markedly distorted from normal pos by the pneumatocele which displaces them upward The enl root shadows increased markings in both lungs and wide i spaces are characteristic of pulmonary emphysema

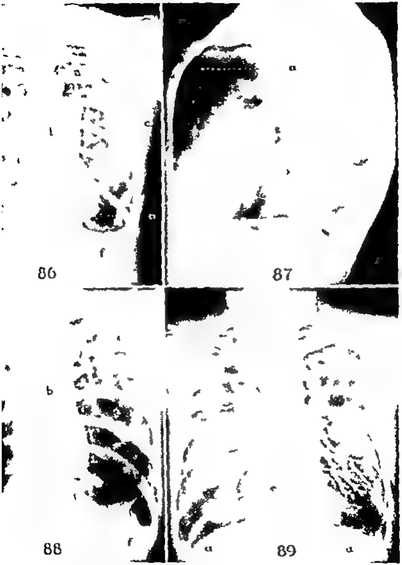
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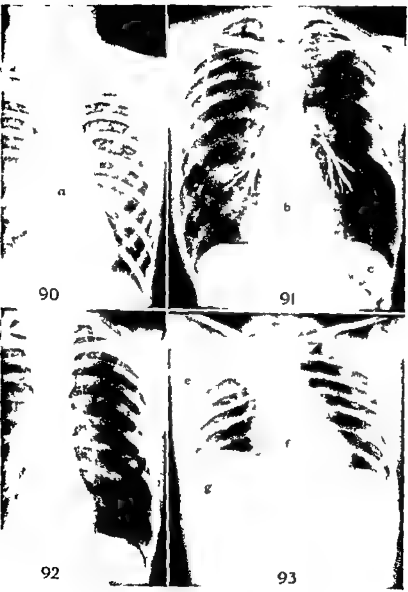
Fig. 90.—Bronchial asthma, allergic origin, typical findings. The low diaphragms, wide interspaces and long heart are all characteristic of emphysema. *a*, hilus s greatly increased in size, partly from enlargement of the p monary vessels, partly from actual inflammatory changes. B chovascular markings are prominent.

Fig. 91.—Bronchial asthma; bronchography with iodized Many of the major bronchi of the second, third and fourth furcations show obstructions (*b*) with a snub-nosed rou appearance caused by the trapping of air. In the areas the contrast medium does pass, as in the right middle lobe the left base, some of the iodized oil extends into the sm bronchi and alveoli, producing a typical arborization pa Where the bronchi are obstructed, the oil is confined to larger bronchi. The large area of excessive radiability at the base (*c*) indicates the presence of a pneumatocele.

Fig. 92.—Bronchial asthma with emphysema and pat atelectasis. The usual signs of emphysema are present. In a tion during an acute phase a patchy area of increased density veloped at the right base (*d*). It is difficult to distinguish s small patches from bronchopneumonia and interstitial p monitis, but in all probability most of those seen on the genogram are due to atelectasis.

Fig. 93.—Bronchial asthma with secondary massive atele In children especially, bronchial asthma may be attended by a phases during which the diagnosis of pneumonia is often A careful study, however, reveals that the areas of density more of the characteristics of atelectasis than of consolida *e*, inferior margin of the right upper lobe crossing above th ond rib instead of the fourth rib as is normal. The lobe is d *f*, trachea and heart displaced to the right. *g*, right diap elevated. This is the characteristic picture of right upper atelectasis. Before onset of this acute process the child had t typical roentgen picture of bronchial asthma with emphyse


a
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e
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g
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93

FOREIGN BODIES IN THE RESPIRATORY TRACT

To determine the presence of a foreign body in the respiratory tract and the secondary effects which it produces the x-ray examination is by far the most important procedure. Films made in both inspiration and expiration are valuable. Lateral views may be very helpful, particularly for localization. Fluoroscopic study, with particular attention to effects of inspiration and expiration on movements of the mediastinum and diaphragms, is essential.

Foreign bodies in the trachea may be visible even though nonmetallic because of contrast between the air in the trachea and the shadow of the foreign body. This is seen particularly in lateral views. Partial obstruction by a tracheal foreign body may cause emphysema of both lungs which is manifested by the usual signs. There may be a paradoxical change in heart size, becoming larger in inspiration, smaller in expiration—the converse of normal.

Foreign bodies in the bronchial tree, if metallic or of dense composition, may be observed by the shadow which they produce. However, unless reasonably good technic is used, the shadow of even a dense foreign body which has been present for a long period may be lost within that of the inflammatory products. Foreign bodies containing no heavy metals or calcium are usually apparent only because of secondary changes.

Obstructive emphysema may be the first sign of a foreign body in a bronchus. It seldom lasts longer than 48 hours but occasionally may be observed for many weeks. It is the result of partial obstruction of the bronchus and is manifested by increased radiability of the affected lobe or lung. Such a change may be obvious in inspiration but is much more striking in expiration because the affected lobe does not empty itself of air while the normal lung expires. The diaphragm on the normal side does not move upward in expiration as it normally should, and a pendulum motion of the mediastinum may be observed during fluoroscopic examination or on comparison of the inspiration and expiration films. The mediastinum moves toward the side of the lesion during inspiration and away from it during expiration. In midrespiration the mediastinum is displaced away from the side of the lesion.

Due to emphysema of one lung or one lobe some shunting ırculation to the remaining normal lung occurs In expiration refore normal areas are even denser than usual owing to the ater quantity of blood passing through them Care must be rcised to distinguish such lobar or contralateral lung densities n during expiration from abnormalities such as pneumonia

With the accumulation of debris around the foreign body or elling of the bronchial mucous membrane or for other rea is complete obstruction of the bronchus supervenes The physema disappears and atelectasis occurs The involved lobe lung becomes much denser than normal the trachea heart d mediastinum are retracted toward the side of the lesion and diaphragm is elevated Compensatory emphysema of the op site lung or contiguous lobe may be seen There is relatively le motion of the mediastinum during inspiration and expira n and the diaphragm on the abnormal side is partially im obilized Exact localization is accomplished by examination two views to demonstrate whether the foreign body is in the un bronchus affecting the entire lung or in a smaller branch ecting one lobe or a segment

With long retained foreign bodies infection develops and id accumulates in the bronchi The lung then becomes con icted and multiple abscesses may appear manifested by areas rarefaction alternating with areas of extreme density Pneu onia or multiple abscesses with fluid levels may be observed large quantities of fluid accumulate in the lung the mediasti um is replaced to its normal position but the diaphragm usually mains elevated Usually so much fibrous tissue contraction kes place that there is still considerable displacement

One of the residua of atelectasis a linear shadow occasionally llows a foreign body Other residua including pleural involve ent from secondary empyema and chronic lung abscess are entified by their specific changes

When multiple foreign bodies are present emphysema of one be or lung and atelectasis of another lobe or the other lung ay be present Furthermore foreign bodies move from one onchus to another producing a variety of findings

Foreign bodies in the trachea are always of the partially structive type In such circumstances there is a paradoxical change in the size of the heart during inspiration and expira which is often diagnostic of the lesion

Fig 94*A* —Foreign body in the trachea a may been aspira 24 hours before examination postero anterior view in deep spiration Note the large size of the heart and low position the diaphragms

Fig 94*B* —Same case postero anterior view in deep expira The heart is definitely smaller than in the inspiratory phase although normally it would be larger The diaphragms remain about the same position The shape of the thorax has cha somewhat There is bilateral emphysema with inability to e pire air from either lung to any extent which produces the found changes exhibited

Fig 94*C* —Same case lateral view *a* foreign body visible the trachea only because the large amount of air around it vides sufficient contrast It could not be seen in the post anterior view Few foreign bodies of this type are clearly v

Fig 95*A* —Metallic foreign body in the right main bronc a thumb tack aspirated by this adult a year before examina postero anterior view upright position *a* foreign body just yond the carina entering the right main bronchus Because it not impeding the passage of air either in or out of the lung t any great extent almost no lung changes are present There w however some physical evidence of trapped air This is ofte the case in such instances and it should be borne in mind th the absence of x ray changes does not exclude a foreign bod although it does exclude any considerable obstruction

Fig 95*B* —Same case lateral view The position of the fore body (*a*) is established more definitely It enters the right ma bronchus just posterior and inferior to the carina Both view are important in such instances to establish the localization un questionably

Fig 96A—Foreign body in right bronchus peanut aspirat 18 hours before examination film in deep inspiration The le lung is slightly denser than the right Diaphragms trachea ar heart are in normal position There is no trace of the foreign bod

Fig 96B—Film made at same time in deep expiration T left lung is more dense as is normal in expiration the left dia phragm has ascended and the heart has shifted to the left Th right lung has retained about the same radiability and the ri diaphragm has remained in approximately the same position as inspiration owing to inability of the right lung to expire its Obstructive emphysema is present

Fig 97A—Foreign body in left bronchus peanut aspir four days previously postero-anterior view in partial inspirati The left lung is more radiable than the right and the right dia phragm is slightly more elevated than the left The heart is in normal position

Fig 97B—Film made at same time in deep expiration No marked elevation of right diaphragm displacement of heart the right low position of left diaphragm and relative radiabil of left lung all characteristic of obstructive emphysema

Fig 98—Multiple foreign bodies in right bronchi peanu film made in deep expiration Most of the right lung shows gre radiability (*c*) than the left but at the right base is an area greatly increased density (*b*) Such changes are observed w two foreign bodies are present In this instance one large f eign body partially obstructs the right main bronchus whil smaller one extending into the right lower bronchus obstru it completely leading to the combination of emphysema a atelectasis on one side A similar process may occur with a sin foreign body if it produces inflammation and resultant muc plugs

Fig 99—Foreign body in right main bronchus metallic b bearing present for several months Note the perfectly spher character of the foreign body (*a*) Changes in the right low lobe (*b*) indicate decreased aeration from partial obstruction the bronchus There is little or no evidence of emphysema

96 A

97 A

96 B

97 B

Fig 100A—Foreign body in left main bronchus bea[illegible] hours after aspiration film in deep inspiration There is a degree of opacity of the left lung owing to extreme atelectasis sulting from complete obstruction of the bronchus The left phragm is markedly elevated (*b*) Cardiac displacement is clear because of rotation This is a typical picture seen water absorbing substances such as beans are aspirated swelling produces early total obstruction

Fig 100B—Same case four hours after removal of f body There is almost complete resolution of the left lung some increase in density remains The diaphragm (*b*) has scended the heart is in normal position

Fig 101A—Foreign body in left bronchus with secondary [illegible] changes postero anterior roentgenogram underexposed T child's history suggested aspiration of a foreign body six mont before It had been neglected owing to lack of correct dia Note extreme density of the left lung and areas of cavitation (in both left upper and right lower lobes The changes on the are due to secondary infection No foreign body is visible

Fig 101B—Film made at the same time with heavier sure Note the hobnail in the left main bronchus clearly seen although invisible in the other film The cavities (*c*) in b lungs and extensive inflammatory processes are clearly delinea Such changes occur with secondary infection from neglected f eign bodies

Fig 102—Foreign body in right lower lobe residual br chiectasis Nine months before this film was made a peanut aspirated and never removed *a* area of atelectasis and chiectasis *d* heart displaced to the right

Fig 103—Foreign body in right lower lobe residual atel tasis A peanut had been removed six weeks *before* this exam tion *a* dense linear shadow characteristic of "platter" atelectas occurring when only a portion of a lobe has been involved and has not expanded Some increase in density surrounding it ind cates pneumonitis

BRONCHITIS BRONCHIECTASIS BRONCHIAL OBSTRUCTION Because of their air content and structural similarity to the surrounding lungs the bronchi are not readily visualized in the roentgenogram except on the addition of contrast medium As a result acute bronchitis often shows no changes In acute laryngotracheobronchitis as in infants and young children some signs such as emphysema atelectasis and bronchopneumonia may be seen in the roentgenograms (see Figs 72 and 73 p 129) Chronic bronchitis also is difficult to demonstrate in the ordinary roentgenogram and the findings are relatively minimal

In bronchiectasis the following distinctive changes may be seen in the ordinary roentgenogram (1) Increase in density and thickness of the linear markings especially those extending to the bases of the lungs The bronchovascular shadows well out in the periphery are more distinct than in the normal subject (2) Stripelike or rounded areas of rarefactions surrounded by thickened rather dense shadows (3) Local areas of density with secondary changes suggesting atelectasis (4) Diffuse irregular mottled areas especially in the bases of the lungs no doubt due to secondary pneumonitis (5) Actual large cavities with fluid levels representing the bronchiectatic abscess (6) In the upper lobes or in bronchiectasis involving the smaller bronchi multiple relatively rounded areas of decreased radiability surrounded by rather thin dense walls These may involve only one lobe or several lobes they may be unilateral or bilateral A spongy or honeycomb appearance of a portion of the lung may also be seen (7) Secondary pleuritic and diaphragmatic changes The roentgen findings incident to such complications are then seen (8) In many cases the lesion lies below the domes of the diaphragm or behind the heart and heavily exposed films must be made to bring them out

To delineate bronchiectasis adequately bronchography with iodized oil is necessary It is impossible to exclude bronchiectasis without such an examination and except in rather advanced cases bronchiectasis may be very difficult to diagnose without the use of a contrast medium With bronchography fairly char

teristic findings may be observed The shadows of the contrast ed bronchi tend to be tortuous and somewhat irregular re- nbling varicose veins In the cylindrical type they are dilated ll beyond normal size In the saccular form the individual di ed bronchi form series of dense rounded grapelike shadows tached to a stem By the same means lesions behind the heart below the domes of the diaphragms can be delineated It is ssible by means of lung mapping to determine the exact calization and extent of the lesion in order to guide surgical tervention In cases of bronchiectasis all of the bronchi must examined because contiguous bronchi frequently are involved thout showing obvious changes in the ordinary roentgenogram is is particularly true of the lingular branch of the left upper be bronchus

Note should be made of the fact that patients without appar t symptoms occasionally exhibit characteristic evidences of onchiectasis Also despite obvious evidence of bronchiectasis the bronchogram a reversal occurs in some cases so that the onchi resume their normal diameter Furthermore a physio gic dilatation of the bronchi which is not truly bronchiectasis ay occur in asthma These bronchi also may return to normal ameter after the obstructive mechanism is removed

The demonstration of bronchiectasis localized in one lobe ould always stimulate a search for a specific obstructive lesion ich as a tumor or foreign body

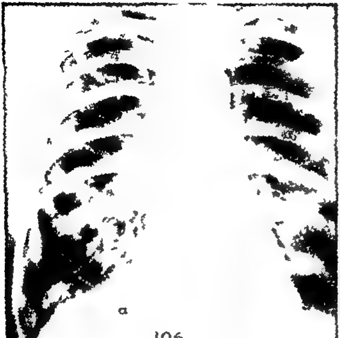
Stenosis of the bronchi of inflammatory or traumatic origin ich as may follow the passage of a foreign body or a peribron ial abscess or pneumonia will produce all of the aforemen oned signs of bronchial obstruction Areas of emphysema telectasis and later bronchiectasis will occur The stenosis itself ay be demonstrated by bronchography or body section roent enography as a narrowed area in the lumen of the bronchus

BRONCHIECTASIS CYLINDRICAL AND CYSTIC

In many cases of bronchiectasis definite changes can be observed in the ordinary roentgenogram It should be noted however that bronchiectasis cannot be excluded by *simple* roentgenography of the chest nor in many instances can it be definitely diagnosed without bronchographic studies with iodized oil Certain distinctive changes in some cases of bronchiectasis are sufficient to permit differentiation from other conditions in the ordinary roentgenogram It should be borne in mind that the basal portions of the lungs are most frequently involved Such areas may be behind the heart or below the dome of the diaphragm where changes are not clearly delineated except by means of contrast medium

Fig 106 —Cylindrical bronchiectasis right lower lobe The root shadows of the lungs are increased and the bronchovascular markings extending into both bases are distinctly thickened They are more conspicuous in the lower than in the upper lobe *a* a number of tubular areas of rarefaction representing the cylindrically dilated bronchi characteristic of bronchiectasis Occasionally chronic bronchitis simulates this picture but no areas of rarefaction as large as those shown here indicate the presence of bronchiectasis

Fig 107 —Cystic bronchiectasis both bases *a* numerous circular or oval areas of decreased density surrounded by thickened walls These are characteristic of the more cystic type of bronchial dilatation The smaller bronchi are dilated in such cases Because their walls are thin the shadows of the walls of the cavities are relatively thin The appearance is quite characteristic and the condition is readily diagnosed from the simple roentgenogram alone



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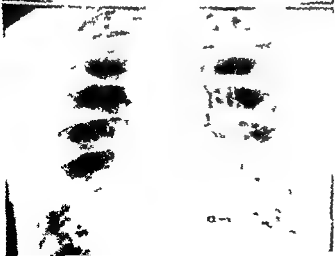


Fig 108—Bronchiectasis with atelectasis and pneumonitis. In severe cases of bronchiectasis there are often associated atelectasis of the involved lobe and pneumonitis Definite cavities (a) with distinctive fluid levels can also be made out These resemble lung abscesses but their localization to the lower lobes, multiplicity and relation to the bronchi identify them as bronchiectatic cavities In this case there were similar findings on the left side although this is not always the case

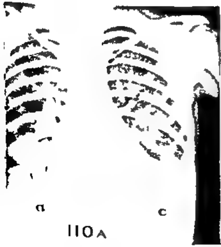
Fig 109—Bronchiectasis with atelectasis and pneumonitis in a child The bronchiectatic cavities are present principally behind the heart (a) The heart is pulled well over to the left side (b) and the trachea is somewhat displaced Emphysema of the left upper lobe compensates to some degree for shrinkage of the left lower lobe This appears to be a unilateral lesion but changes on the right side cannot be excluded from such an examination alone bronchographic mapping of both lungs is necessary to exclude bronchiectasis in other lobes

Fig 110A—Bronchiectasis bilateral with atelectasis in a child postero anterior view Note the areas of cylindrical infection and pneumonitis (a) at the right base The left diaphragm is elevated (c) owing to atelectasis at the base of the left lung but few changes are observed in the lungs except just above the diaphragms since most of the process lies behind the heart

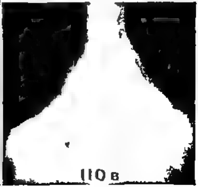
Fig 110B—Same case planigram 4 cm from posterior chest wall The large cavities (a) are much better shown than in the ordinary film Both saccular and cylindrical dilatations of the bronchi are seen on the left side behind the heart (a) Body section roentgenography may be of great value in delineating the exact nature of the process if bronchography with iodized oil is not available or is contraindicated By this means changes behind the heart or cavities in the area of the pneumonitis may be demonstrated

108

109



110A



110B

Fig 111 —Cylindrical bronchiectasis postero-anterior bronchogram a tubular dilatation of the left lower lobe Most of the changes are retrocardiac the ordinary roentgenogram appeared normal No abnormality was found on the opposite side The demonstration of a localized process is important because surgical extirpation of such a lobe may effect a cure

Fig 112 —Saccular bronchiectasis postero-anterior bronchogram All the bronchi have been filled here a procedure not recommended Extensive saccular bronchiectatic cavities are well shown in the left upper lobe and behind the heart in the lower lobe All of the right bronchi are filled out and normal thus indicating the localized character of the process and the possibility of cure by extirpation of the left lung

Fig 113A —Bronchiectasis cylindrical and saccular bronchogram right side only Bronchography of the left side had been done 72 hours before After evacuation of the oil on the left the examination was repeated so that the right side could be delineated *a* tortuous dilated bronchi resembling varicosities characteristic of cylindrical bronchiectasis Only a few saccular areas are present and only the lower bronchi are involved On the left the residue of the iodized oil and areas of pneumonitis around the obstructed bronchi produce a variety of rather bizarre finger like shadows (*b*)

Fig 113B —Same case bronchogram portion of left lung only Note the marked saccular dilatations of the left lower lobe bronchi (*b*) nearly all of which are involved The left upper bronchus has also been filled the lingular branch (*c*) shows irregular tortuous cylindrical dilatation which is of great importance because it must be dealt with surgically The advantages of lung mapping are clearly apparent By means of bronchography it could be demonstrated that the medial portion of the right lower lobe the inferior portion of the left upper lobe and the entire left lower lobe were affected

[Bronchiectasis Bronchography *continued on page 164*]

111

112

113 A

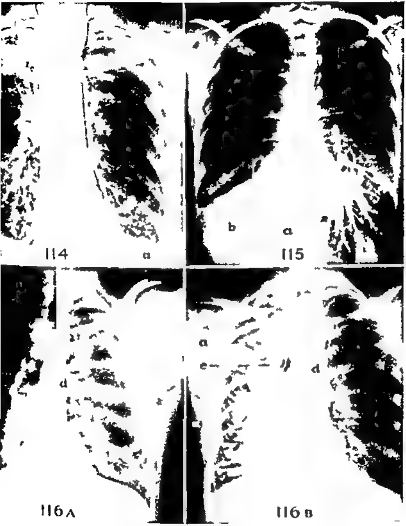
113 B

Fig 114—Saccular bronchiectasis cystic type bronchogram Dilatation of the smaller bronchi from bronchiectasis produces thin walled cavities which often are numerous involving a ... of the lung and giving a cystic appearance These have been designated by various terms and are thought by some to be congenital Multiple saccular areas especially well shown at the bases (*a*) are filled with iodized oil but also contain gas

Fig 115—Bronchiectasis with atelectasis severe grade; bronchogram ... cylindrically dilated tortuous bronchi which indicate presence of bronchiectasis of moderate degree in the left lower lobe On the right side the whole lower lobe is atelectatic producing a characteristic triangular paravertebral shadow with a concave upper border (*b*) The bronchi in this lobe were filled but a heavier exposure would have been required to demonstrate such bronchiectatic areas in the dense atelectatic fluid filled lobe

Fig 116A—Cystic bronchiectasis incident to bronchial compression by calcified peribronchial lymph nodes postero-anterior roentgenogram with filtration of x rays striking normal lung which permits overexposure of dense right lung while preserving normal contrast in the left lung The obstruction of the right main bronchus (*d*) by the multiple calcified peribronchial lymph nodes (*e*) could be clearly made out even in this ordinary roentgenogram By means of the heavy exposure the numerous cavities in the right lung are clearly delineated

Fig 116B—Same case bronchogram The outline of the right main bronchus (*d*) is somewhat better delineated because of the coating of its wall with iodized oil *e* calcified lymph nodes compressing the bronchus The multiple cystic type of cavities in the right lung filled with iodized oil (*a*) are characteristic With the patient upright the gas rises to the upper surface giving a level between the iodized oil and the gas Note how the heart is markedly displaced toward the right despite the cystic character of the process A good deal of shrinkage of the right lung caused this displacement



114

115

116A

116B

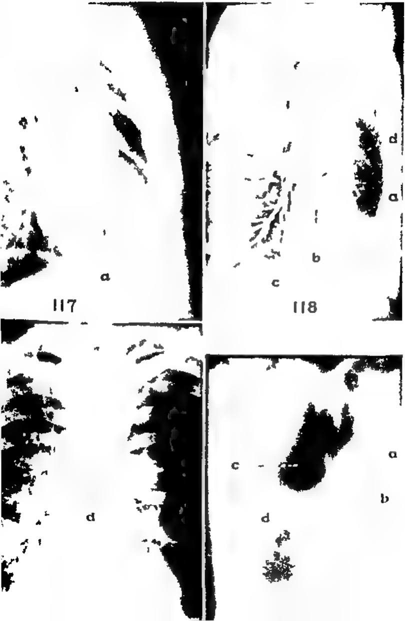
BRONCHIAL OBSTRUCTION The films shown be[low] demonstrate the variety of methods available for study of bro[n]chostenosis and its sequelae In addition to simple postero-anter[ior] films in the lateral position bronchography with iodized oil a[nd] body section roentgenography aid in establishment of anato[mic] changes in bronchial obstruction

Fig 117—Bronchial obstruction right middle lobe late[ral] view Stenosis developed after an adult aspirated a pea[nut] Atelectasis of the right middle lobe shown here is characterist[ic] The lobe instead of being roughly triangular is oblon[g] density superimposed on the cardiac shadow The inferior bor[der] (a) is markedly concave because of shrinkage of the lobe a[nd] compensatory expansion of the lower lobe The upper border [is] lower than normal owing to expansion of the upper lobe

Fig 118—Bronchostenosis with atelectasis and bronchiecta[sis] of middle lobe bronchogram lateral view a upper border [of] middle lobe depressed Lower border is not as clearly se[en] b cylindrically dilated bronchi in middle lobe d stenosis [of] right middle lobe bronchus demonstrated by contrast mediu[m] c cylindrical bronchiectasis in right lower lobe

Fig 119—Bronchostenosis right middle lobe simulating c[ar]cinoma postero anterior bronchogram The history strongly s[ug]gested bronchial carcinoma and the original film indicat[ed] atelectasis of the right middle lobe Right middle and lo[wer] lobe bronchi were demonstrated by bronchography d compl[ete] stenosis of middle lobe bronchus of smooth character App[ear]ance simulates carcinoma but is more regular Surgical extir[pa]tion of the middle lobe disclosed a caseous peribronchial abs[cess] proved to be tuberculous

Fig 120—Bronchostenosis inflammatory body section roe[nt]genogram Planigram made 10 cm from the posterior chest w[all] reveals the entire anatomy in this case of bronchiectasis result[ing] from bronchial obstruction due to peribronchial inflammat[ion] a trachea b right main bronchus c dilated cavities in l[ung] representing cystic bronchiectasis d stenosis of bronchus [...] shown by soft tissue shadow compressing the air filled lung [...]


a
117
d
a
b
c
118
d
a
c
b
d

LOCALIZED BRONCHIECTASIS To determine the presence of bronchostenosis and the exact localization of bronchiectasis a variety of roentgen procedures often must be used. Roentgenograms in various positions, bronchography and body section roentgenography should all be utilized.

Fig 121A —Localized bronchiectasis right middle lobe, from inflammatory bronchostenosis ordinary postero anterior roentgenogram upright position *a* a very vague irregular density in the region of the right middle lobe. Throughout the lungs are numerous small densities probably calcified disseminated childhood tuberculosis or possibly histoplasmosis. The lesion of the middle lobe may well be the result of lymph node enlargement from this old process exerting pressure on the bronchus.

Fig 121*B* —Same case postero anterior view position of lordosis. By this method the change in the axis of the right middle lobe disclosed a triangular area of density containing numerous rarefactions (*a*). This maneuver many times is of great value in demonstrating a lesion which otherwise could not be seen. It is evident that the size of the right middle lobe is greatly diminished and that it contains numerous cavities.

Fig 121*C* —Bronchogram postero anterior view. The oil was introduced by the passive method and the right middle lobe also filled out. Characteristic saccular and cylindrical bronchiectasis in the middle lobe is well shown. The outline of the lobe as a small triangular structure lying medially is clearly delineated. Compare with Figure 121*B*.

Fig 121*D* —Bronchogram right lateral view. The small size of the right middle lobe and the saccular and cylindrical bronchiectasis within it are effectively shown. Further lung mapping indicated that the other bronchi were not involved. Such demonstration of a localized lesion is of the greatest importance because it establishes clearly the feasibility of surgical extirpation of the suppurative process in the lung.

This case illustrates the *middle lobe syndrome* which is not uncommon and may be secondary to lesions of early childhood affecting either the bronchus or the parenchyma of the middle lobe

121A

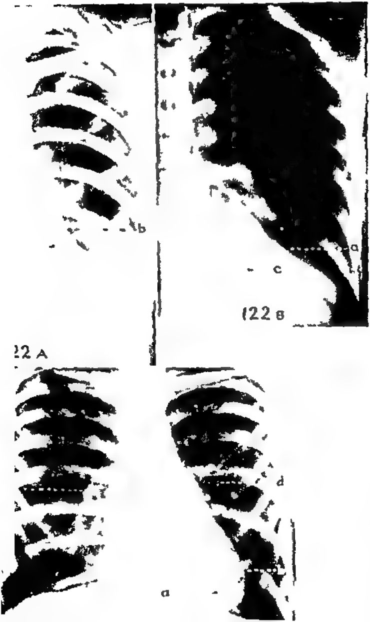
121B

Fig 122A —Bronchostenosis left main bronchus from pa monia of early childhood postero anterior view Bronchi involves especially the left lower lobe producing in density *a* border of the left lower lobe which is shrunken a triangular perivertebral shadow superimposed on the shadow *b*, left border of the heart displaced to the left. Some the numerous irregular densities clearly appear to be beyond limits of the lower lobe

Fig 122B —Same case body section roentgenogram The sibilities of anatomic diagnosis by this method are well onstrated *a* lateral margin of the left lower lobe which shrunken to a perivertebral triangle behind the heart *c* are the numerous bronchiectatic cavities visible throughout the a tatic lobe

In further studies of this case bronchography with lung m ping was utilized The left main bronchus was stenotic, the lower bronchus was markedly contracted and the left upper bronchus also especially the lingular branch was found to involved The right lung was entirely free Pneumonectomy necessary and was accomplished with full recovery The h findings bore out the roentgen diagnosis completely

Fig 123 —Bronchostenosis with atelectasis of the left lo lobe postero anterior view Typical changes with atelectasis the lower lobe are clearly demonstrated There is a triangul area of increased density behind the heart with its hypote (*a*) lateral its long side toward the midline the short side tow the diaphragm which is not elevated The cardiac shadow (t extends beyond this perivertebral triangle The root of the le lung (*d*) is distinctly smaller than that of the right (*e*) the r sult of medial displacement of the vessels to the lower lobe T left lung as a whole is much more radiable than the right owi to compensatory emphysema of the upper lobe The combinati of these findings is characteristic of left lower lobe atelectasis ar helps to differentiate it from mediastinal empyema perivertet abscess and tumor of the left lower lobe Surgical extirpation c the left lower lobe disclosed inflammatory bronchostenosis prob ably originating in a foreign body



b
a
c
122 B
22 A
d
a

PULMONARY ABSCESS Whether acute or chron[ic] pulmonary abscesses usually present changes in the roentgen[o]gram which are of diagnostic importance At the outset the ap[]pearance is that of localized pneumonia There is an area [of] density not sharply demarcated often with a hazy radiat[ing] margin It is not confined to any one lobe and has a rather fea[th]ery appearance Such a process occurs shortly after the devel[op]ment of an abscess from aspiration an embolus or pneumon[ia]

As destruction develops communication with a bronch[us] takes place following which an area of cavitation can be m[ade] out Films made in the upright position then demonstrate a cl[ear] area above and the shadow of fluid below As the cavity [be]comes more chronic its wall becomes more sharply demarcat[ed] from the surrounding tissues A fluid level may be demonstrated in the upright position or in the lateral decubitus position, th[e] level adjusting itself to be parallel to the long axis of the bod[y] The exact localization of such a cavity can be determined b[y] films in various positions and by fluoroscopic examination

Generally speaking a nontuberculous lung abscess shows a rather thick irregular wall and a large amount of fluid within it Occasionally the cavity is so filled with fluid that gas cannot b[e] seen In other instances after considerable evacuation throu[gh] the bronchi the cavity may be almost filled with gas and re[]peated examination is necessary to verify the observation

Cavities are occasionally multiple several appearing in on[e] or more lobes In some instances particularly in the staphylococ[c]cic pyemias following certain pneumonias and after a shower of small emboli which have become infected multiple smal[l] abscesses occur throughout both lungs At the outset these of e[n] are round fairly well defined densities simulating to some exten[t] nodular metastases in the lungs or well demarcated bronche[o] pneumonia With the development of destruction areas of rad[i]ability appear within these cavities and fluid levels are also seen

Cavitation occurs in the lung in the presence of fungi esp[e]cially in actinomycosis and with bacterial infection and a variet[y] of other diseases Often it is difficult to differentiate betwee[n] these various etiologic factors from the x ray examination alon[e]

The most important diagnostic problem as far as a single abscess is concerned is differentiation from a tuberculous cavity. It must be emphasized that often this distinction cannot be made since they may resemble each other closely and the sputum examination must be relied on for the final diagnosis. However certain features tend to distinguish the two. Nontuberculous abscesses are more likely to occur in the lower than in the upper lobes; this is the converse of tuberculosis. Usually with tuberculosis there are other areas suggestive of the disease around the cavity or in other portions of either lung. Fluid is more common in nontuberculous abscess and in larger quantity. The capsule of a nontuberculous abscess is likely to be thicker and less regular.

Carcinoma of the lung may manifest itself as a solitary abscess. Usually the wall is thicker and more nodular than in an inflammatory process. Tumor obstruction of a bronchus may cause abscesses in segments of lung supplied by that bronchus.

Cysts of the lung when infected may produce findings similar to those of a lung abscess and are sometimes difficult to distinguish. The cyst is usually larger, there is less contiguous and collateral inflammatory process and the wall is distinctly thinner and more sharply defined. Obviously the history and repeated roentgen examinations are of the greatest importance in differentiation. In some instances distinction between an infected cyst and abscess can be made only by biopsy of the cavity wall.

Attempts at bronchography for the diagnosis of abscess are often unsuccessful because the cavity does not fill with the contrast medium. By this means however definite areas of bronchiectasis can often be demonstrated in contiguous bronchi. Bronchostenosis may be shown to involve the bronchus supplying the abscessed segment. Its character may suggest the correct diagnosis, particularly in diagnosis of carcinomatous abscess.

For surgical drainage localization of the exact segment of the lung affected by the abscess should be attempted by careful study of radiographs made in the postero-anterior, oblique and true lateral projections. Occasionally lung mapping by bronchography is necessary to delineate the segment accurately.

Fig 124—Pulmonary abscess two weeks after , early stage postero anterior view Diffuse irregular density be made out in the medial portion of the right lung Its poor defined outer borders and diffuse homogeneous character s gest pneumonia In the upper portion however there is an ar of rarefaction (a) which is the beginning of breakdown of th process Pneumonia in the resolving stage may have a someway similar appearance but persistence of the findings usually ma that an abscess is developing

Fig 125A—Pulmonary abscess 10 days after tonsillectom Only the right upper lobe where the abscess occurred is show There is a rounded area of increased density with beginn sharp definition of the periphery a fluid level between above and fluid below A large amount of fluid is present in cavity which helps to distinguish it from a tuberculous pro b relatively thick wall of cavity In many instances howe it is virtually impossible to distinguish such a process fro tuberculous cavity except by the history bacteriologic st and eventual changes (Courtesy of Dr H E Wilmot Litchf Minn)

Fig 125B—Same case four days later The cavity size diminished greatly and the fluid level is not now clearly parent The gas filled space however is still present and fairly thick wall surrounding it is seen (b)

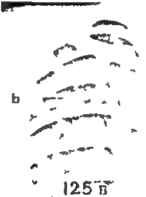
Fig 125C—Re examination seven days later 25 days tonsillectomy The cavity is small and shows only a cons ously thick wall (b) Later films showed only a small sc linear area of density remaining

Fig 126—Multiple pulmonary abscesses in a child Tr otomy was done because of laryngeal obstruction but aspi of foreign material resulted in abscess Multiple cavities c made out in both lungs Note the fluid levels (a) the sharply defined rounded wall of each cavity and the diffus of consolidation surrounding them

[Pulmonary abscess continued on page 176]

124

125 A



125 B

126

Fig 127A —Pulmonary abscess two weeks after cholecystomy anteroposterior view supine position A triangular of density corresponding fairly well to the position of the middle lobe suggests a consolidation Within it some faint of lesser density can be made out but these are not clearly fined

Fig 127B —Same case following day upright position the fluid level (*a*) the gas rising upward the fluid below and thick inflammatory wall around the abscess cavity The upright position is always necessary for demonstration of an abscess is difficult to distinguish such a lesion from an infected cyst the lung but the irregular character of the cavity the marked thickness of the wall and the surrounding inflammation aid differentiation

Fig 128A —Pulmonary abscess aspiration one week after bulbar palsy postero anterior view upright position The location and extent of the cavity may be well demonstrated by in both postero anterior and lateral views The massive cavitation density in the left lung just medial to the heart can be made The appearance suggests that it is central actually it is medial as shown in the lateral view (Fig 128B) Both fluid level (*a*) and the thick wall around the cavity (*b*) seen There are irregular densities within the shadow of the cavity some of which are superimposed from the lung lying in front of it and some of which represent actual granulations exudate within the pocket

Fig 128B —Same case lateral view upright position cavity is seen to be almost at the posterior chest wall involving the apical portion of the lower lobe The fluid level (*a*) and thick wall (*b*) are again shown Demonstration of the exact position is of great assistance to the surgeon in approaching the cavity Differentiation from encapsulated empyema with a bronchial fistula is difficult Such pockets however usually are more sharply outlined show less inflammation in the surrounding lung have a more lateral position and are accompanied by more striking involvement of the peripheral pleura Differentiation from a necrotic carcinoma of the lung must also be made

127A

127B

128A

128B

Fig 129 —Congenital cyst right lung in a boy 12, poster anterior view upright position The cyst had become infected s that the patient had all the symptoms of pulmonary suppurati *a* margin of lung cyst Note characteristic thin wall and abse of pleural thickening in this area *b* fluid level with gas abov and fluid below *c* trabeculae extending through cyst cav which are characteristic and help to differentiate from encap lated empyema Operation showed this cyst to occupy the mi lobe only but it was so large that it compressed the upper above and lower lobe medially and occupied most of the he thorax Lobectomy was followed by good recovery

Fig 130A —Congenital cyst first observed at birth subseq infection and secondary changes postero anterior view su position The multiple cystic areas contain so much gas that e in the supine position the cavities are distinct The thin, rath spherical shadows representing cyst walls occupying a lar portion of the right lung are well shown When first obser the cysts were filled with fluid infection occurred later Pn monia with secondary empyema was diagnosed and a rib re tion was done leaving a defect in the rib (*d*)

Fig 130*B* —Same case lateral view upright position Thr distinct cysts are seen each with fluid level (*b*) Thin walls o the upper pocket are well shown (*a*)

Fig 130*C* —Postero anterior view upright position *a* w of several cysts *b* fluid level of one pocket The lung was total extirpated because of marked suppuration with complete reco ery

Fig 131 —Nonputrid abscess of the lung postpneumonic s ulating cyst Extensive gas and fluid filled pockets are seen the right lung *b* fluid level *c* walls of several pockets Differe tiation of this type of lung tissue destruction usually occurrin children from congenital cyst may be difficult In this case th films made before onset of the infection gave no evidence of lesion The process cleared spontaneously in contrast with lun cyst which persists

[Cysts of the lung Congenital *continued on page 182*]


c
b
129


d
130 A


b
b
130 B


c
b
131

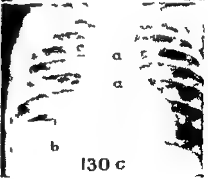

a
a
b
130 C

Fig 132A —Infected lung cyst simulating encapsulated pyema postero anterior view upright position The patient had many attacks of so called pneumonia and empyema se rib resections had failed to produce permanent drainage o suppurating cavity Note relatively thin wall of the pocket (a fluid level (*b*) indicating gas and fluid and communication a bronchus Heart is displaced to the right No generalized pl thickening elevation of diaphragm or retraction of mediast has occurred as is usual in encapsulated empyema with a l chopleural fistula

Fig 132B —Same case after drainage through a rib resec with catheter in the cavity lateral view *a* thin cavity *d* rubber drainage tube Fluid has been almost entirely remo but despite drainage the cyst remains large and filled with Persistence in the face of repeated drainage is character Lobectomy later revealed a typical congenital cyst

Fig 133A —Congenital air cyst of the lung in infant months postero anterior view Symptoms were noted at b First films made two months after birth showed an air pocket At this time an enormous air sac occupies the entire hemithorax Cyst walls (*a*) and trabeculae through the cyst are well demonstrated The cyst was so large that it displ trachea heart and right mediastinal pleura into the left c causing mediastinal hernia (*e*) Resulting marked compressio the left lung caused striking cyanosis

Fig 133B —Lateral view The anterior cyst wall (*a*) tra (*f*) and its bifurcation below are well shown

Fig 133C —Anteroposterior view after suction Size of cyst was greatly reduced It is seen to involve only the mi lobe the other two lobes having been compressed and displ by marked expansion of the cyst The mediastinal hernia (133A) is reduced Pneumonectomy led to full recovery (See 338 p 367 for end result)

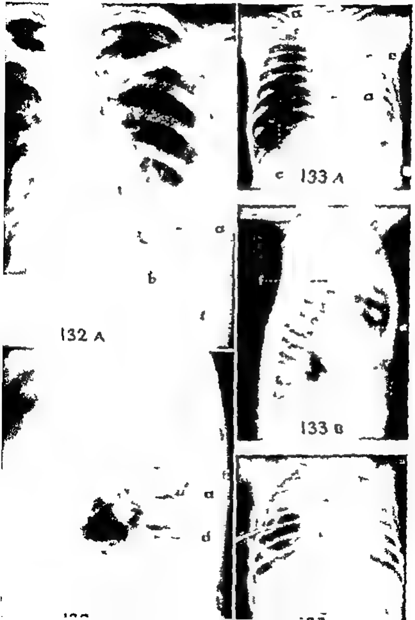
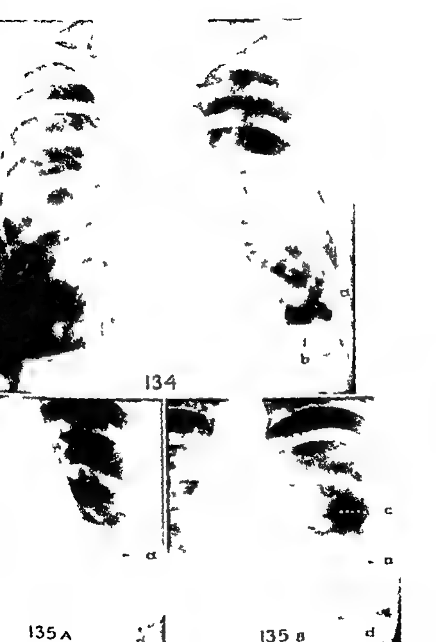

132 A
133 A
133 B

Fig 134 — Chronic emphysema with pneumatoceles po[...] anterior view On the right side a large area of rarefaction a[...] base represents a pneumatocele At the left base is a pocl[...] gas and fluid Originally this was simply an air cyst or [...]matocele resulting from ectasia of the alveoli commonly [...] with emphysema but it became infected The fluid level and wall of the pocket (*a*) are shown The appearance is si[...] to that of a congenital lung cyst but the condition is d[...]guished by the history and presence of generalized emphy[...] Considerable pneumonitis is also present on the left side (c[...]*pare with* Fig 89 p 143 Figs 91 and 92, p 145 and Fig[...] p 183)

Fig 135A — Pleuropericardial cyst postero-anterior [...] *a* large mass overlying the left diaphragm and extending [...] the left border of the heart close to the apex *d* superimp[...] shadow of the overlying breast The cyst is filled with flu[...] no gas bubble is made out This type of cyst which is essen[...] pleural does not communicate with a bronchus

Fig 135B — Roentgenogram after artificial pneumothorax was injected into the pleural cavity to demonstrate definitel[...] extrapulmonary character of the cyst *a* shadow of the [...] much the same as in the postero anterior view *c* lung coll[...] away from the cyst *d* overlying breast shadow Artificial p[...]mothorax is an excellent means for distinguishing between [...]pulmonary and extrapulmonary lesions and in some instanc[...] of crucial importance The cyst was later removed surgically [...] proved to be a classic pleuropericardial cyst containing fluid



134

135 A

135 B

SILICOSIS The earliest roentgenologic changes in silicosis are not specific because repeated infections, inhalation of other dusts and even advanced age may produce a similar appearance. For this reason a history of exposure is of great moment. Characteristic of this stage is a faint granular appearance which is fairly uniform throughout both lungs. As the disease advances definite nodules which are specific appear.

Fig. 137.—Diffuse fibrosis of both lungs, classified as nonspecific. The patient, aged 66, had been a copper miner for 10 years. He had not been exposed to silica for 30 years. The early characteristics of silicosis—enlarged root shadows, increased linear markings and faint granular appearance of both lungs—are well illustrated. This type of fibrosis may occur with diseases other than silicosis, but when there is a definite history of exposure to silica the diagnosis of first stage silicosis may be considered. A definite diagnosis of silicosis should not be made from such findings alone.

Fig. 138.—Silicosis, nodular stage. The patient was a sandblaster for five years. Definite silicotic nodules are well shown. Numerous small, almost miliary densities extend from apex to base in a rather uniform, diffuse fashion. The root shadows of the lungs are somewhat enlarged. The linear markings are not clearly apparent because they are masked by the numerous nodules distributed throughout the lungs. This is one of the most characteristic findings in silicosis. However, it may also occur with lung involvement from less harmful dusts, as siderosis or chalicosis. The extent of the nodulation has little relation to the individual's disability.

The distinction of this lesion from other miliary lesions is often difficult, and the clinical history and immediate findings must be relied on. For example, acute miliary tuberculosis, acute bronchiolitis and miliary metastases to the lungs may produce a somewhat similar picture.

[Pneumoconiosis *continued on page 190*]

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The nodular stage of silicosis may advance to an extreme, c[illegible] abling degree Another form occurs however in which the o[illegible] standing features are strandlike linear shadows most promin[illegible] in the inner areas of the lungs Either form may eventuate [illegible] coalescence of the densities They tend to involve the inner t[illegible] thirds of the lungs with emphysema in the outer portion Ge[illegible] eralized emphysema pleural thickening and diaphragmatic a[illegible] hesions are prominent It is notable that the disease progres[illegible] long after exposure to the dust has ceased eventually right h[illegible] enlargement and finally right heart failure may supervene

Fig 139—Silicosis far advanced nodular type The patie[illegible] was a sand blaster with six years exposure of severe grade T[illegible] nodular type of silicosis is well demonstrated extensive, ne[illegible] large densities being present throughout both lungs from apex [illegible] base Some plaque formation (*a*) has already occurred The p[illegible] tient was cyanotic and in a severe state of dyspnea when a[illegible] mitted There is beginning enlargement of the right heart [illegible] Right heart failure ensued and the patient died of it some th[illegible] months after the roentgenogram was made This is a severe gra[illegible] of the nodular stage and illustrates the fact that symptomatica[illegible] a patient may be in a late stage of silicosis although the so-call[illegible] second stage of nodulation dominates the roentgenographic p[illegible] ture

Fig 140—Silicosis second to third stage The patient, ag[illegible] 70 had been a foundry worker for 13 years but had not be[illegible] exposed for 20 years The beginning third stage of silicosis is w[illegible] illustrated Plaques (*a*) have begun to form at various sites E[illegible] larged root shadows are not conspicuous but increased dens[illegible] of the linear markings is striking There are some nodular are[illegible] but coalescence into masses (*a*) is quite characteristic S[illegible] coalescence will eventually occur in the left lung Some e[illegible] physema is already established as shown by characteristic h[illegible] radiable areas of the lungs at both bases Despite the fairly [illegible] tensive changes the patient had relatively minor symptoms

[Pneumoconiosis *continued on page 192*]

139

In the late stages multiple dense fairly well defined pl… like shadows are characteristic. Often there is an area of … emphysema lateral to the density of such a coalescence … tasis of a lobe may also occur. Tuberculosis is a common … plication bringing with it changes in the roentgen findings … make diagnosis more difficult. Both the silicosis and the tu… losis may be atypical but cavitation and calcification are not common. Silicosis alone apparently may produce either cavitation or calcification but their presence should strongly suggest superimposed tuberculosis. Asbestosis differs from ordinary silicosis … that there is more fibrosis and retraction and less nodule formation.

Fig. 141.—Silicosis, third stage. The patient was a sand blaster and stone cutter for 30 years. The massive plaque formation is striking. This is a characteristic location of the coalescent … sis which tends to retract away from the periphery and … form a dense mass. A similar process is occurring in the … upper lobe but has not retracted to the same degree. Some … lation can be made out in the remaining portions of the l… together with a distinct increase in the linear pattern of the l… indicating fibrosis. Notice the calcification in the peribronchial lymph nodes (*c*) which is not uncommon in silicosis. Moder… emphysema is also present.

Fig. 142.—Silicosis, third stage, with typical plaque formation. The patient was a coal and copper miner for 34 years … suffered from dyspnea for 10 years. The classic coalescent plaq… are well demonstrated, a large number of them being present … both lungs. The typical location of the density of such coalesce… is shown in the upper lobes (*a*). The plaques have retra… from the periphery and there is emphysema (*b*) of the outer p… tions of the lungs. Some nodulation also can still be made … and some increase in the linear markings. Emphysema is also … parent from the low position of the diaphragms and the incr… radiability at the bases of the lung. Note the calcification in … peribronchial lymph nodes on the right side (*c*).

[*Pneumoconiosis continued on page 194*]

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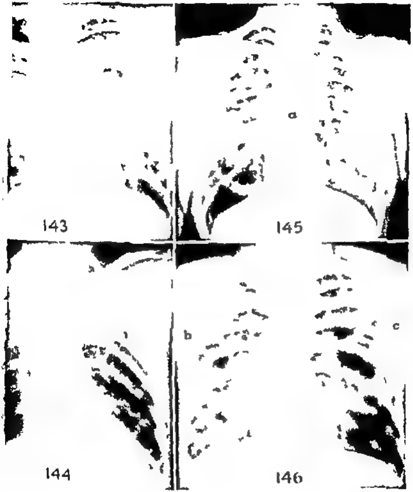
Fig 143 –Silicosis advanced stage in a granite cutter sive coalescence has occurred in both lungs which are dense Some nodular areas can still be made out, helping identify the character of the process Note the tendency medial position of the dense shadows Frequently such coalescences result from superimposed infections either tu culous or nontuberculous None was found in this case The tient died of right heart failure In some cases extensive in ment almost to this degree is attended by relatively mode degrees of dyspnea

Fig 144 –Silicosis, advanced stage with atelectasis The tient aged 75 was a granite cutter but had not worked for years yet he eventually died of right heart failure There been gradual retraction of the fibrotic process to the upper with atelectasis Note the high position of the roots of the and extreme density in both upper lobes

Fig 145 –Silicosis with calcification of lymph nodes lesion resulted from hard coal mining for 30 years Fibrotic nodular densities are scattered diffusely throughout both especially above The nodular shadows are characteristic emphysema is present The classic "eggshell" calcification of peribronchial lymph nodes which is common with certain of silicosis is well shown

Fig 146 –Silicosis with superimposed tuberculosis Th a history of eight years work as a stone cutter Recently h sis had appeared and tubercle bacilli were found in the There are typical nodules areas of coalescence and plaque mation (*b*) especially in the right upper lobe The superim tuberculosis causes a marked change in the character of t process A large cavity (*c*) in the left upper lobe helps to clear the complicating tuberculosis It should be pointed out, howe that silicosis occasionally produces cavitation resembling tuber losis

The effects of inhalation of beryllium are more acute usua more severe The chemical effects are diffuse and produce nu ous amorphous irregular shadows scattered throughout the lu The history is of prime importance in diagnosis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a
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b
c
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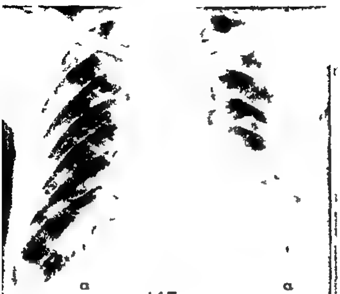
LIPOID PNEUMONITIS The pneumonitis caused by aspiration of oily materials, particularly mineral and animal oils, produces fairly distinctive changes. They are largely fibrotic, with retraction and atelectasis. Massive areas of density simulating lung tumors may be observed. The character of the changes depends on the stage of the process and the quantity of oil aspirated. In children lipoid pneumonitis may occur as an acute process from aspiration of milk or cod liver oil. In adults, however, it is usually a long-standing, slowly progressive process, and repeated roentgen examinations reveal increasing changes.

Fig. 147.—Lipoid pneumonitis in an elderly person resulting from aspiration of mineral oil taken for constipation. There are irregular densities at both bases. On the left side the diaphragm is somewhat elevated and there is evidence of beginning atelectasis. The densities are rather mottled. Usually they are bilateral, as shown here, but vary somewhat in extent. They are almost invariably basal. Findings such as these should always suggest lipoid pneumonitis. (Courtesy of Dr. John Noble, Ancker Hospital, St. Paul.)

Fig. 148.—Lipoid pneumonitis, massive, postero-anterior view. A man aged 73 had been using mineral oil nose drops for many years. The symptoms were suggestive of a lung tumor. The large dense mass at the right base also suggests a tumor; it represents a paraffinoma. Lipoid pneumonitis is also present in the left base but is hidden by the heart shadow. The retraction of the heart, bilateral involvement confined to the base and the extremely dense shadows suggest the diagnosis. (Courtesy of Dr. M. B. Hanson, Minneapolis.)



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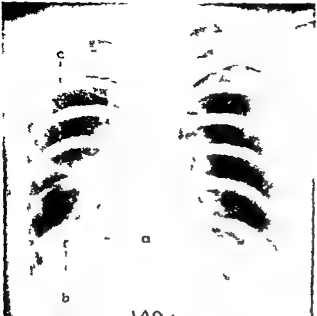
RADIATION FIBROSIS Pneumonitis with dif- fibrosis in the lungs follows irradiation such as that usually ... for carcinoma of the breast or for tumors and other path... processes within the lung The process is usually progressive ... manifests itself most characteristically by irregular areas of ... density with elevation of the diaphragm and retraction of ... mediastinum toward the side of the lesion In the early st... the appearance may resemble atypical pneumonia The roent... changes often appear long after irradiation was given Rapid ele- vation of the diaphragm is strongly indicative of the cond... Particularly characteristic is the sharp "tenting" of the diaphr... almost invariably present Usually the findings are unil... since the radiation is usually to one side only It must be di- tinguished from the lymphogenous or infiltrating type of c... cinomatous metastasis The distinction is not always simple b... cause it is frequently in patients who have had a carcinoma of breast that such metastases occur The unilateral character of ... process marked tendency to elevation of the diaphragm and l... of hilar enlargement help to identify it as radiation fibr...

Fig 149A—Radiation fibrosis from treatment of carcin... of the breast postero-anterior roentgenogram made six mon... after irradiation over the right lung Note the marked fibr... of the lung (*a*) extending into the right base The diaphra... already somewhat elevated and presents a distinct peak ... middle portion (*b*) There are conspicuous thickening of ... interlobar fissure (*c*) and marginal fibrosis of the contigu... lobes The tendency to localization to the irradiated area h... to identify the process

Fig 149B—Same case two months later The process is p... gressive so that the diaphragm is more elevated (*b*) and ... heart and trachea are displaced to the right The fibrosis has ... tended to involve a large portion of the upper as well as ... lower lobe

[Lung fibrosis *continued on page 200*]



149A

Fig 150 –Nonspecific fibrosis left lung This ... result of an old unresolved pneumonia with involvement ... pleura and development of lung abscesses Diffuse dens... volves the entire left hemithorax Some areas of lesser ... can be made out at the periphery *b* trachea distinctly ... to the side of the lesion *c* diaphragm markedly ele... shown by the gas bubble in the stomach *d* esophagus ... contrast medium displaced to left Later the bronchi ... with iodized oil and extensive bronchiectasis was ...

Fig 151 –Nonspecific fibrosis right lung from ... sis The changes are long standing as indicated by the scoliotic thoracic spine which has adjusted itself to the ... in the lung Diffuse density involves the entire right hem... The heart is retracted somewhat to the right and the ... an extreme degree (*b*) The left lung is greatly distended ... mediastinal hernia (*c*) projects into the right hemithorax ... er exposures in such cases may often demonstrate the ... bronchus and areas of cavitation within the lung

PULMONARY DISEASE ASSOCIATED WITH PA... ATIC FIBROSIS In young children with chro... brosis or cystic disease of the pancreas marked associated ... changes may occur They are often quite typical in their ... involvement of both lungs their resemblance to fibrosis, ... presence of secondary bronchiectasis and emphysema and ... definite enlargement of the lung roots

Fig 152 –Extensive lung changes with congenital cystic fi... sis of the pancreas in a boy aged 5 Note the marked ... ment of the roots of the lungs (*a*) and the diffuse nodular fibrotic densities extending throughout both lungs especially ... the upper lobes and well out to the periphery The process ... rather symmetrical and uniform Some emphysema is shown ... the low diaphragms and distention of the lungs at the bases

Fig 153 –Lung changes with cystic fibrosis of the ... in an infant *a* markedly enlarged hilus shadows Rad... from these shadows into the periphery of the lungs are ... areas of increased density characteristic of the process Not... symmetry of the process and the evidence of emphysema

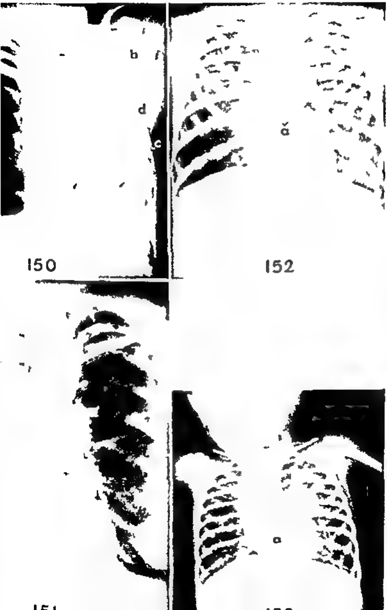

b
d
c
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Fig. 153-1.—Diffuse interstitial fibrosis of both lungs of specific inflammatory origin. The increased linear markings their sharp dense character are apparent. Note the presence emphysematous blebs in many areas. Increased linear mark may be produced in some cases of lymphogenous metastasis usually in such circumstances the root shadows of the lungs even larger and the process is more uniform. Repeated exa tions in interstitial fibrosis will usually reveal further contr of portions of the lungs with compensatory emphysema of o areas. (*Compare with* Figs. 137, 145, 152 and 153.)

Fig. 153-2.—Hemosiderosis pulmonum in a child with s penic (iron deficiency) anemia and repeated hemoptysis. Mu ple episodes of bleeding into the lungs produce fibrosis ch acterized by the very fine granular, somewhat stippled, s metrical bilateral shadows which are apparent here in middle portions of the lungs. The appearance differs from t of the usual interstitial pneumonitis or interstitial fibrosi inflammatory origin in that it causes not increased linear shad but much finer stippled nodular lesions simulating those p duced in certain types of pneumoconiosis. A similar proc occurs with mitral disease. *Compare with* Figs. 156 and 15

153 1

PULMONARY MYCOSES Fungus infections of the lungs are not rare; they include particularly coccidioidomycosis, blastomycosis and actinomycosis. Histoplasmosis, usually manifested by multiple calcifications and calcified lymph nodes (discussed on p. 252), may also present itself as acute or chronic pneumonia with findings similar to those of other fungus infections. The characteristic feature of such infections is the tendency to widespread lesions, abscess formation, involvement of the mediastinal lymph nodes and imitation of tuberculosis.

Coccidioidomycosis, although endemic only in California and Texas, is encountered occasionally in any region. The roentgen findings depend on the stage of the lesion. A primary lesion, often upper lobar, fan shaped and appearing to radiate from the hilus, is common. The lymph nodes are enlarged. Diffuse nodules may then occur. In the secondary stage extensive ... cavitation and miliary spread are seen. Many lesions imitate tuberculosis so perfectly that they can be distinguished only by immunologic or bacteriologic studies. In many cases coccidioidomycosis produces a local area of density in the subclavicular area exactly like that seen in early tuberculosis.

Fig. 154.—Coccidioidomycosis. Four weeks after onset; anterior view. Multiple nodular areas (*a*) suggesting bronchopneumonia or multiple abscesses are seen in both lungs. This is one type of coccidioidomycosis in the primary stage. Complete resolution occurred.

Fig. 155.—Coccidioidomycosis, primary infection, later stage. The diffuse infiltrative process in the left upper lobe (*a*) is suggestive of a caseous type of tuberculosis. The peribronchial lymph nodes are enlarged. Occasionally such lesions are multiple. The changes may progress or regress much more rapidly than those of tuberculosis and complete resolution is more likely to occur. Mycotic infection must always be considered when findings are suggestive of tuberculosis. (Courtesy of Dr. ... Carter, Los Angeles County Hospital.)

[Pulmonary mycoses continued on page 206.]

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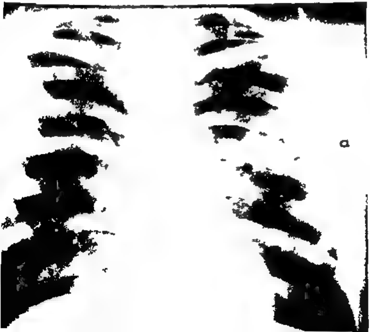

Fig 161–1 —Sarcoidosis of parenchyma of lung Diffuse infiltrations in both lungs resembling interstitial fibrosis occur with sarcoidosis as shown here The lymph nodes may be enlarged and the infiltration of the lung may accompany them The lymph node shadows however may disappear but the fibrosis of the lungs remains and may continue more permanently with some disability resulting Without the enlarged lymph nodes it is extremely difficult to distinguish this type of fibrosis from other interstitial nonspecific lesions However there is usually a history or evidences of marked lymph node enlargement in the early stages of the process (*Compare with* Figs 145 and 153-1)

Fig 161–2 —Erythema nodosum. In this condition enlargement of the peribronchial and peritracheal lymph nodes exactly similar to that seen in sarcoidosis may be observed There is more tendency to bilateral peritracheal enlargement than in sarcoidosis but otherwise the findings are almost identical and cannot be distinguished except by the clinical evidence The peritracheal and peribronchial lesions on both sides show characteristic shadows of enlarged lobulated lymph nodes Note the minimal old tuberculous lesion in the right subclavicular area (*a*) (*Compare with* Figs 160 and 161)

PULMONARY TUBERCULOSIS In few diseases is x ray examination of more value in diagnosis than in pulmonary tuberculosis Its value is based on the following facts

1 When there are symptoms of chronic pulmonary tuberculosis x ray changes are nearly always found The absence of x ray signs in the presence of symptoms is the strongest evidence against the diagnosis of pulmonary tuberculosis A negative x ray examination in this circumstance is the most conclusive evidence of absence of tuberculosis of the lungs

2 In acute miliary tuberculosis on the contrary symptoms usually precede x ray signs by at least a week occasionally by as long as six weeks With symptoms suggestive of acute hematogenous or bronchogenic dissemination therefore negative x ray findings do not exclude the disease

3 Routine examination of presumably normal individuals with or without positive tuberculin skin reactions often reveals unsuspected tuberculosis However in absence of symptoms a negative diagnosis is not conclusive since a minimum of 10 weeks after ordinary infection is required for x ray changes to appear There is a latent period during which roentgen findings may be negative although tuberculosis is developing

4 In routine examination of presumably normal individuals with a positive tuberculin skin reaction a small percentage is found to have a variety of lesions both active and healed If the x ray examination is negative the positive skin reaction has no immediate clinical significance Absence of roentgen signs however does not exclude the residua of first infection tuberculosis

5 Next to positive sputum characteristic x ray findings are the most definite evidence of presence of pulmonary tuberculosis

6 In many cases there may be x ray evidence of pathology in the lungs but the tuberculous character is doubtful The nature of the process must be determined by repeated roentgen examination or by other methods Rarely is one justified in diagnosing pulmonary tuberculosis on the basis of one x ray examination

7 X ray signs of pulmonary tuberculosis do not necessarily indicate the activity or quiescence of the lesion In some cases

the activity can be determined but in many it is impossible to decide on the stability of a lesion without repeated studies

8 The progress can be followed by repeated study The extent, character and location of the process can be accurately determined

9 Information on effects of treatment especially pneumothorax and thoracoplasty as well as chemotherapy is afforded

10 Absorption and healing of reinfection parenchymal tuberculosis as well as of first infection lesions may be so complete that no changes remain in the film Often however some residual fibrotic or calcified scar can be observed

11 Fluoroscopic examination cannot be relied on for diagnosis of early tuberculosis although it may be helpful and is certainly superior to physical examination in the delineation of small lesions The roentgen technic previously outlined is of first importance in diagnosis of minimal lesions

Certain terminology should be considered in discussing tuberculosis The term first infection or childhood tuberculosis is commonly used and an effort is made here to distinguish between such a lesion and the reinfection type usual in adults This may be an artificial distinction but it has practical value

First Infection Tuberculosis in Children

The characteristic manifestation is an area of consolidation in the lung often homogeneous resembling pneumonia It is usually subpleural and may vary widely in size and location With such a consolidation there is usually enlargement of the tracheobronchial lymph nodes draining the region, manifested by widening or irregular lobulation of the superior mediastinum or of the root of the lung Re examination may indicate that the infiltration rapidly becomes smaller although the time required for resolution is much longer than that for ordinary pneumonia Irregular dense shadows may remain with linear bands radiating from them they gradually contract until a small scar is produced more often calcification results Calcification produces rounded very dense irregular stippled shadows in the periphery of the lung often so small as to escape detection Enlarged hilus

glands may remain as faint shadows rather poorly seen more often they calcify, giving a striking irregular density of stippled nonhomogeneous character

Rarely in children active tuberculous pneumonia develops and spreads rapidly giving dense irregular, poorly defined shadows throughout the lungs Cavitation may supervene In some children the reinfection type of tuberculosis is also observed

Tuberculosis of the lymph nodes is occasionally so out of proportion to the parenchymal lesion as to seem to be the primary process Enlargements are most common in the superior mediastinum and may be bilateral Infiltration in the lung field sometimes occurs as a direct extension from the lymph nodes and it is difficult to distinguish one from the other

Calcified nodules in the hilus or around the larger bronchi are usually due to healed first infection tuberculosis Many are difficult to see in the postero anterior view and oblique and lateral views or fluoroscopic examination in various positions is necessary to disclose them Other conditions such as histoplasmosis and coccidioidomycosis may also produce calcification

Great care must be exercised to avoid overdiagnosis of childhood tuberculosis from apparent enlargement of hilus lymph nodes Variations in the blood vessels may simulate lymph node swelling vessels seen on end are often mistaken for calcified lymph nodes

Reinfection Tuberculosis

Reinfection tuberculosis takes a somewhat different form The characteristic lesion can be seen as early as 10 weeks after exposure Typically the changes are in the subclavicular area, producing a characteristic shadow However certain types of pneumonia simulate it closely

It is characteristic of tuberculosis in general that the lesions are multiple of varying types, and tend to occur in the upper lobes Sometimes the involvement is basal in the adult as well as in the child All varieties of pathology from simple consolidation to fibrosis atelectasis emphysema cavitation and calcification occur Any individual case may exhibit all of these lesions

The various types of tuberculosis may be described as follows (1) Exudative tuberculosis, which in general causes feathery irregular dense somewhat hazily outlined often diffuse ill defined shadows (2) Productive lesions, which cause rather dense more sharply defined discrete shadows (3) Fibrotic and fibroid types which usually represent healed or healing lesions with dense coarse bandlike shadows from the periphery toward the hilus (4) Caseation which produces dense, homogeneous densities often with local areas of cavitation (5) Pneumonic types which resemble either lobar or bronchopneumonia but are more widely distributed and less well demarcated to lobes or lobules (6) Cavitation, which produces an area of decreased density often rounded frequently ragged with complete loss of lung markings within it and a capsule of increased density around it In some cases a fluid level is seen (7) Calcification which produces stippled irregular nonhomogeneous extremely dense areas usually representing healing

The acute forms of tuberculosis include the following (1) Disseminated lesions, which cause coarse fairly small dense shadows scattered along the linear markings of the lungs sometimes involving both lungs but occasionally confined to one lobe or one lung Usually the primary lesion causing the bronchial dissemination is found (2) A spread from a previous lesion which is often made out as a rather soft looking hazy poorly defined density independent of the older lesion from which it arose (3) Acute miliary tuberculosis which has a characteristic "snowstorm" appearance with numerous small nodules scattered diffusely throughout both lungs (4) Tuberculous pneumonia which may closely simulate lobar or bronchopneumonia

Tuberculosis of the bronchi may give all of the evidence of bronchostenosis including emphysema atelectasis bronchiectasis and finally complete breakdown

Healing is exhibited by increased sharpness and density of the shadows streaked character contraction of the lung with angular retraction of the trachea and, finally calcification

Stability or instability is difficult to establish by x ray study alone Repeated studies are helpful but far from accurate

FIRST INFECTION TUBERCULOSIS This charateristic example of first infection tuberculosis shows its regressi with time and eventual healing as a calcified area in the pare chyma of the lung Much of the density seen originally m actually represent the so called "epituberculosis" or atelecta associated with the early tuberculous lesion of childhood On th first examination it is difficult to differentiate from pneumon but the slow resolution enlarged lymph nodes and relative la of symptoms distinguish it

Fig 162A —First infection tuberculosis first examinatio postero anterior view The child aged 2 with minor symptom was followed until the age of 6 The tuberculin skin reaction ha recently become positive Note the area of increased density the left lung (*a*) apparently extending from the root toward th periphery The margins are indistinct and the process appears involve both upper and lower lobes There is moderate enlarg ment of the mediastinum in the superior portion on the left sid suggesting enlarged lymph nodes

Fig 162B —Lateral view made at the same time The con solidation obviously infiltrates both the upper lobe (*a*) and th apex of the lower lobe (*b*) exemplifying the typical manner which tuberculosis at this stage in contrast with ordinary pne monia tends to pass over the interlobar lines

Fig 162C —Same case four months later postero anter view The consolidation (*a*) has diminished considerably b there is still generalized decrease in aeration of the whole l lung There is some enlargement of the peribronchial lym nodes medial to the actual focus (*a*) in the lung

Fig 162D —Same case over three years after onset poster anterior view The mass in the left hilus (*a*) has become calc fied as indicated by the density of the shadow its irregular out borders and its slightly stippled character The generalized de creased aeration of the left lung has disappeared and both lung are about equal The mass in the parenchyma of the lung is still present but is hidden by the lymph nodes behind which it lies

The various manifestations of tuberculosis in childhood the first infection are demonstrated here

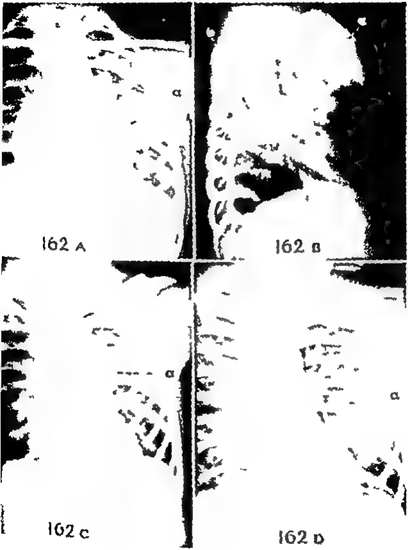
a
162 A
162 B
a
162 C
a
162 D

Fig 163 —Childhood tuberculosis in an infant *a* typical consolidation in the middle portion of the left lung *b* wide superior mediastinum such as might occur with an enlarged thymus gland In this case the shadow is due to enlarged peritracheal lymph nodes a characteristic of first infection tuberculosis The mediastinal shadow together with atypical distribution of the parenchymal density identifies the lesion

Fig 164 —First infection tuberculosis in a child beginning of healing *a* area of consolidation in the medial portion of the right lung just distal to the root and above the diaphragm *c* a number of nodules already showing density characteristic of calcium Regression is already occurring with the tendency to calcify characteristic of the first infection

Fig 165 —Childhood tuberculosis with massive consolidation and miliary spread The process involves the right lower and middle lobes (*a*) There is probably some atelectasis suggested by the elevated diaphragm The mediastinal nodes are also somewhat enlarged especially in the peritracheal region on the right side Diffusely scattered through both lungs are fine miliary densities especially well shown on the left side The appearance is characteristic of miliary spread In this case of pulmonary first infection tuberculosis there was a hematogenous miliary spread which eventuated in fatal tuberculous meningitis The miliary lesions are often difficult to see and usually are not observed until the consolidation in the lung is well developed

Fig 166 —First infection tuberculosis with massive mediastinal lymph node enlargement *a* small focus of tuberculosis in the parenchyma of the lung *b* markedly enlarged peritracheal lymph nodes especially on the right side *c* conspicuously enlarged peribronchial lymph nodes The enlargement of the lymph nodes shown here in association with a small area of consolidation frequently occurs in first infection tuberculosis

[Tuberculosis First infection *continued on page 220*]

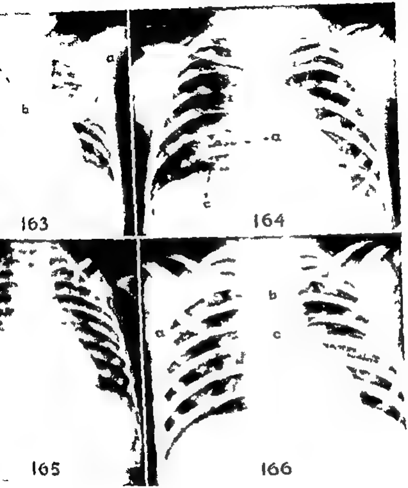
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Fig 167A —First infection tuberculosis in a young ad posteroanterior view left lung only *a* rounded sharply zone of increased density in the parenchyma of the lung, of a tuberculoma or the residuum of first infection tuber It was first observed at age 18 There is slight evidence minimal amount of calcification within the density but the ess is not completely calcified even at this stage seven after the infection was first noted *b* calcified peri lymph nodes showing the typical irregular outline and stippled nonhomogeneous density which are characteristic of the process The lymph nodes often calcify more rapidly than does the original parenchymal lesion

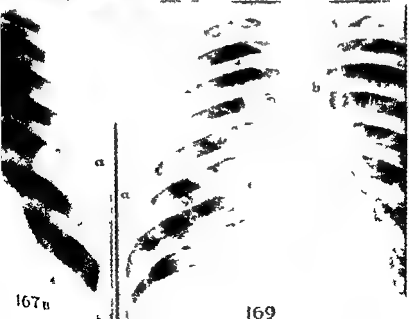
Fig 167B —Same case three years later after repeated expectoration of "stones" *a* focus in the lung with calcification more definite Distinction from a solitary peripheral tumor nodule can be made by observation of the calcification *b* small amount of calcium remaining in the lymph nodes The reduction in size of the calcified lymph nodes as a result of extrusion through the bronchi is well seen in the two films

Fig 168 —Calcified peribronchial lymph nodes probably first infection tuberculosis in an adult postero anterior view *b* calcified lymph nodes in the right peribronchial region *c* normal blood vessel in the left peribronchial region Contrast the appearance of these two densities which are typical of the difference between that of the normal blood vessel and the irregular stippled shadow of the calcified lymph node On fluoroscopic examination a blood vessel changes its appearance completely with rotation of the patient the calcified lymph node remains the same

Fig 169 —Calcified first infection parenchymal tuberculosis and calcified peritracheal lymph nodes (Ghon's complex) *a* small rounded irregular calcified tuberculous focus in the lung no doubt a healed childhood infection *b* calcified peritracheal lymph nodes Note how easily these might be lost within the central shadow if the exposure were insufficient

Recent investigations indicate that some of the cases with calcification resembling those shown here are due to histoplasmosis rather than tuberculosis Distinction is best made by skin tests

167A 168



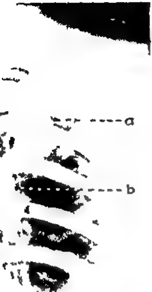
167B 169

Fig 170 —Reinfection tuberculosis in symptomless nurse early stage postero anterior view left upper lobe only a area of increased density in the subclavicular region characteristic of the process It is flufflike nonhomogeneous near the periphery and in typical position Extending from this toward the root of the lung is a series of bandlike shadows of increased density (*b*) typical of the drainage band which often accompanies reinfection tuberculosis The hilus of the lung on this side is slightly increased in size

Fig 171 —Same case nine years later left upper lobe Most of the process in the subclavicular area has absorbed although a number of small nodules (*a*) remain A similar nodule in the apex just above the clavicle (*a*) has a density characteristic of calcification The drainage bands (*b*) can still be made out The size of the root of the lung has diminished somewhat

Fig 172 —Minimal tuberculosis in a young adult 12 weeks after first exposure to tuberculosis postero anterior view left upper lobe only a nodule in left apex characteristic of the lesion A small line of increased density extending toward the root of the lung represents the drainage band Such lesions must be present for some time before their tuberculous nature is established

Fig 173 —Minimal tuberculosis reinfection type in a young adult 16 weeks after first exposure to tuberculosis A roentgenogram seven weeks earlier showed only a small nodule in the right apex which by itself probably would not have been identified Nevertheless the finding demonstrated that a lesion of this kind can be seen roentgenologically within about 11 weeks after the first exposure In the film shown here the lesion (*a*) extends in roughly triangular form from above the clavicle in the apex to somewhat below the clavicle (*a*) and a drainage band (*b*) extends toward the root of the lung The size of the infiltration was eventually reduced somewhat but it persisted for many years



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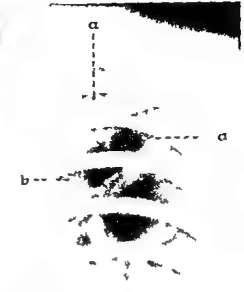

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Fig 174A—Tuberculosis of minimal extent in an i' aged 21 16 weeks after first exposure postero-anterior view upper lobes only Previous films had been entirely negative and a film made six weeks before this one approximately 10 weeks after first exposure to tuberculosis was also entirely normal The lesions (a) are seen on both sides On the right is a round, somewhat irregularly shaped consolidation in the parenchyma of the lung partially hidden by the rib shadows Only with the best technic can a faint density of this kind be clearly ascertained, but its demonstration at an early stage is of the first importance In such cases stereoscopy is highly desirable The drainage band (b) helps to establish the nature of the process On the left side the lesion (a) is less sharply defined representing the typical [illegible] shaped density with a drainage band (b)

Fig 174B—Same case three years later postero-anterior view upper lobes only The character of the lesions has changed considerably A good deal of the exudative process around them has disappeared and they have taken on a more sharply defined nodular appearance This indicates the tendency to healing The drainage bands (b) are still visible The persistence of the lesions over such a length of time is of first importance in determining the tuberculous nature of the process During the whole period the patient had few symptoms occasionally exhibiting a moderate rise in temperature Roentgenograms at frequent intervals indicated a marked variation in the lesion with more exudation at certain times and more productive nodulation at other times until it finally became a scarred process

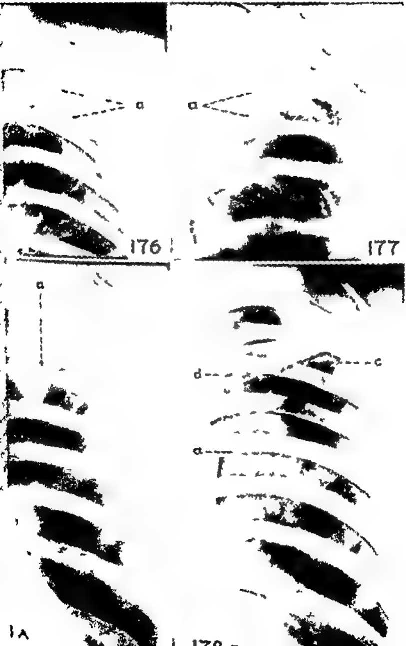
Fig 175—Minimal tuberculosis in a young adult early stage postero-anterior view upper lobes only Note the nodular lesion in the right apex (a) and the multiple fibrotic and nodular lesions in the left apex (a) The drainage band (b) from the lesions on the left side is well shown Such findings indicate a more productive less exudative process and greater tendency to fibrosis

Fig 176 —Minimal tuberculosis reinfection type in a young adult postero anterior view left upper lobe only *a* characteristic lesion of early tuberculosis Two or three nodular areas of increased density are seen well out at the periphery of the lung Note the typical subclavicular location irregular outline and lack of homogeneity Linear shadows (*b*) representing perilymphatic infiltration and thickening of the bronchial walls are visible

Fig 177 —Minimal tuberculosis reinfection type nodular and exudative in a young adult postero anterior view right upper lobe only Two soft hazy shadows representing an exudative process and small denser more sharply defined nodular shadows representing a productive process (*a*) can be seen The drainage band is not clearly demonstrated

Fig 178A —Minimal tuberculosis with progression, early stage left upper chest only The patient was exposed to tuberculosis and repeated examinations were made at six month intervals When this roentgenogram was made the patient had no symptoms the examination being purely on a routine basis Unfortunately the small lesion (*a*) covered by the shadow of the anterior end of the first rib and the drainage band (*b*) were overlooked Stereoscopic views at this time might have made the lesion more apparent but it should not have been missed on this examination

Fig 178B —Same case six months later The patient had distinct symptoms a cavity (*a*) was present pneumothorax (*c*) had been induced and adhesions (*d*) between the cavity and the chest wall are apparent The result of failure to observe the small early lesion was a serious crippling tuberculosis which necessitated thoracoplasty and other surgical procedures


a
a
176
177
a
c
d
a
1A
178

SIMULANTS OF TUBERCULOSIS Certain types pneumonic infiltrations in the upper portions of the lung esp cially in the subclavicular areas frequently simulate early pu monary tuberculosis and lead to errors in diagnosis Such sim lants can best be ruled out by repeated examination for th disappearance of the nontuberculous as compared with the pe sistence of the tuberculous, lesion is the most important differe tiating factor Such pneumonic infiltrates were commonly se among inductees into our military forces and are also se among personnel of other groups in whom tuberculosis is su pected In some cases the shadows are the result of Loffler's sy drome or eosinophilic pneumonia in others atypical pneumon influenzal pneumonia and other infections may cause them. view of the frequency of such lesions the diagnosis of tuber losis when the shadows are minimal should not be made on t basis of one examination alone The value of re examination illustrated in the cases shown here

Fig 179A —Inductee apparently *symptomless* routine roe gen examination of chest postero anterior view upper lobes on The nodular irregular area of density (*a*) *in* the right sec interspace is quite characteristic of incipient tuberculosis (Fig 174 p 225 and Figs 176 and 177 p 227) The bronchi s on end (*b*) are normal

Fig 179B —Same case six months later upper lobes only N the almost complete disappearance of the lesion previously served in the second interspace with only a faint linear sha (*a*) remaining to indicate the earlier consolidation The bro have not changed The *resolution* of the process and absence appreciable residua indicate a nontuberculous inflamma (*Courtesy of Dr R G Allison Minneapolis*)

Fig 180 —Postero anterior view upper lobes only A de *shadow* (*a*) *in the right* subclavicular region closely resem early reinfection tuberculosis in the young adult The patient a nurse who had low grade fever and mild symptoms sugge of minimal tuberculosis Within three weeks the lesion had c pletely disappeared without leaving any residua indicating nontuberculous nature

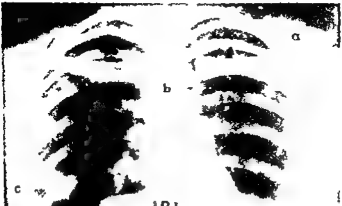

b
179 A
179 B
a
a

MODERATELY ADVANCED TUBERCULOSIS For purposes of classification pulmonary tuberculosis can be divided into minimal moderately advanced and far advanced stages The first indicates a lesion occupying an area down to the anterior second rib. The second stage is reached when an area equivalent to the anatomic space from apex to second rib on both sides is equaled, if the lesion goes below the second rib on one side or if very small cavities are present Any involvement beyond this is far advanced The division is essentially anatomic and has little to do with incipiency or activity of the process A lesion may be classified as stable or unstable on the basis of x ray findings In general stability is more likely in a productive lesion activity in an exudative process

Fig 181 —Pulmonary tuberculosis nodular and fibrotic, and tuberculoma posteroanterior view upper half of chest *a* nodular sharply defined lesions in left apex indicating healing sta of minimal tuberculosis *b* drainage bands This is characteristic of minimal tuberculosis as exudate absorbs and productivity increases *c* large typical tuberculoma in right lung probably first infection tuberculosis incompletely calcified

Fig 182 —Pulmonary tuberculosis moderately advanced, bilateral reinfection type Numerous discrete dense irregular shadows are present in both upper lung fields Note the rather nummular character of the lesions especially those designated *a* Such lesions are often called the round focus type These isolated nodules are easily mistaken for metastases They are usually in the upper lobes and often as here are associated with numerous fibrous tissue bands which help to identify the process

Fig 183 —Pulmonary tuberculosis moderately advanced reinfection type exudative *a* rather hazy diffuse densities in right upper lobe *b* drainage bands Such shadows are typical of an active exudative relatively recent process *d* older lesion in right apex with fibrotic strand of much more productive character *e* several nodular lesions in left apex no doubt due to a much older process The contrast between the older more fibrotic processes (*d* and *e*) and the exudative lesions (*a*) is well shown

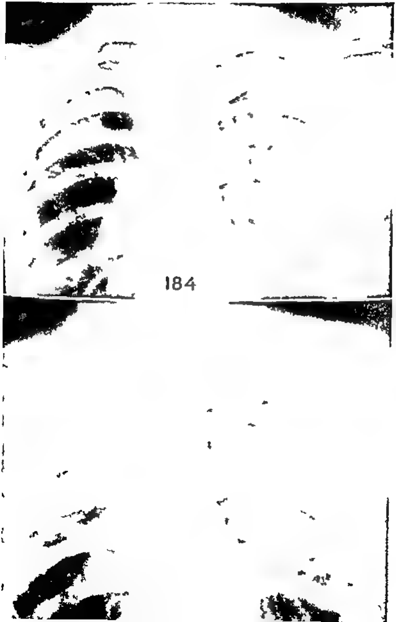


181

182

Fig 184—Pulmonary tuberculosis reinfection type upper two thirds of lungs The granular and streaked shadows in the right subclavicular area are typical of a fibrotic lesion In the left apex and subclavicular areas the nodular and linear densities are characteristic of a productive rather low grade type of tuberculosis The patient had no symptoms or physical signs whatever at the time this film was made the lesion being discovered during routine examination of hospital personnel Later, however, after a pregnancy the process lit up and a severe advance in the lesion resulted with marked symptoms Lesions manifested even by such relatively innocent looking shadows as these may be potentially dangerous

Fig 185—Pulmonary tuberculosis moderately advanced bilateral reinfection type exudative and productive Note the extensive nodular lesions in the right upper lobe almost obliterating the apex and extending well down into the second interspace The small sharply outlined rounded densities interspersed with linear streaks are characteristic of hard, productive tuberculous lesions. On the left side in the upper portions is a similar process of lesser degree Between the anterior second and third ribs a more diffuse homogeneous density denotes a more exudative type of lesion This is typical of an advanced process in which several types of tuberculous infiltration are present



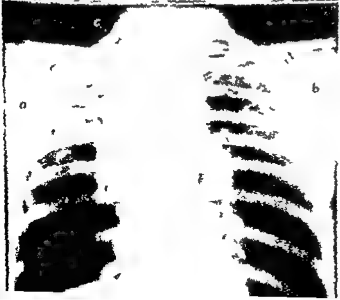
184

FAR ADVANCED TUBERCULOSIS A striking feature of the x-ray findings of pulmonary tuberculosis is the multiformity of the lesions Thus nodular fibrotic exudative pneumonic cavitating and calcifying lesions may all be found in the same case if the lesion is well advanced Recognition of the different forms is important particularly because they may give an indication of the activity or quiescence of the process In general sharply defined hard looking nodular fibrotic streaked or calcified lesions are productive and may be stable Soft appearing pneumonic hazy ill defined shadows connote activity Repeated examination with comparison of the changes is by far the best means of determining activity a lesion which is changing whether progressing or regressing should be considered active

Fig 186—Pulmonary tuberculosis far advanced exudative and fibrotic Extensive lesions are shown in both lungs There are fibrotic bands (*a*) in the right apex where the pleura is distinctly thickened Note the streaked and nodular character of the process Many smaller nodules are scattered through the rest of the lung On the left side the infiltration extends well down toward the base of the lung with numerous areas of more homogeneous density in addition to the nodular and streaked lesions The former are more exudative than the latter

Fig 187—Pulmonary tuberculosis far advanced bilateral with cavitation An extensive consolidating process on the right side contains three large areas of rarefaction (*a*) each typical of a cavity These areas are somewhat rounded have thick walls and contain an area of diminished density Surrounding them is an area of greatly increased density fairly characteristic of pneumonic consolidation The mediastinum and heart are retracted to the right side indicating a long standing process with a good deal of fibrosis The trachea (*c*) is markedly angulated to the right side because of the scar formation On the left side is a local exudative area (*b*) with a definite drainage band extending from it toward the root of the lung

186



CAVITATION This is an important feature of pulmonary tuberculosis An area of lesser density with or without a fluid level and with a fairly thick dense ringlike shadow around it usually indicates a cavity It is important to determine their presence because a cavity indicates activity and usually a far advanced lesion The distinction from nontuberculous cavities can best be made by sputum examination but upper lobar localization collateral shadows indicative of tuberculosis relatively little fluid in the cavity and a moderately thick wall are all suggestive of a tuberculous process

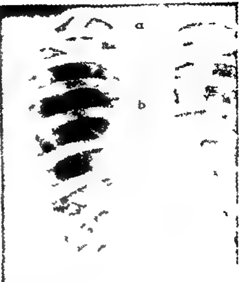
Fig 188A—Pulmonary tuberculosis with small cavity right side of chest only An area of infiltration (*a*) in the right apex is represented by a rather rounded somewhat homogeneous area of increased density quite characteristic of tuberculosis of relatively recent origin and unstable nature

Fig 188B—Same case two months later The cavity is clearly apparent within the area of infiltration in the right apex with a definite capsule (*a*) and a fluid level (*b*) The interface between gas and fluid is clearly shown in the upright position by the fluid level

Fig 189A—Cavitation in pulmonary tuberculosis increasing left side of the chest only A fairly large cavity is shown in the left upper lobe The capsule (*a*) is rather thick and dense and a very small amount of fluid is present at the base of the cavity with a fluid level (*b*) A small somewhat calcified nodule (*c*) representing an older more healed process is clearly seen in the left apex A similar nodule is seen just within the margin of the film in the right apex

Fig 189B—Same case one year later Note the marked increase in size of the cavity in the left upper lobe the capsule (*a*) of which appears somewhat thinner A small amount of fluid (*b*) is seen in the inferior part of the cavity The calcified areas (*c*) in the apex have not changed The expansion of such a cavity may be due not entirely to greater destruction of lung tissue but rather to obstruction to the escape of air so that the surrounding lung is displaced and compressed This probably represents a tension cavity

188A



188B

189A

189B

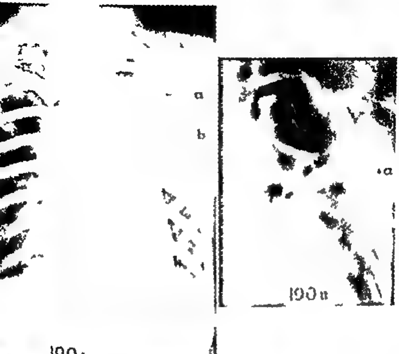
The demonstration of cavities in the lungs may be grea assisted by the use of body section roentgenography which t to eliminate obstructing shadows In some cases this is the only means by which a cavity can be detected

Fig 190A —Pulmonary tuberculosis left upper lobe extensive postero anterior view A single area of rarefaction (*a*) within the striking area of density in the upper lobe is visible but is not clearly defined and it is difficult to determine its extent The other lesion (*b*) is clearly exudative or pneumonic On the right side are a definite exudative lesion (*c*) in the apex and somewha lesser lesions in the subclavicular area

Fig 190B —Same case body section roentgenogram of le upper lobe The large cavity (*a*) in the apex is clearly outlined below it are two smaller cavities (*a*) not seen in the ordinar film These are typical of cavitation in exudative tuberculosi The facility with which the cavities are brought out in the pla gram is clearly illustrated

Fig 191A —Pulmonary tuberculosis cavitation postero-ante rior view An area of irregular rarefaction (*a*) overlies the right first rib It is so close to the rib that it is made out with grea difficulty Marked thickening of the pleura at the base of the le lung is clearly seen

Fig 191B —Same case body section roentgenogram of ri apex The outline of the cavity (*a*) is clearly made out and exudative process around it also is better delineated The fa that the cavity is not part of the rib but superimposed on it i clearly indicated Demonstration of cavities is often of great im portance because it modifies the therapy and the outlook



190A 190B

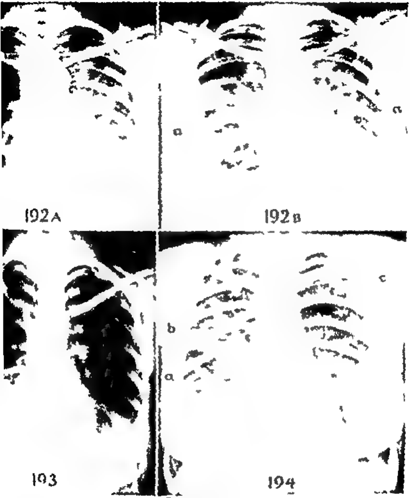
191B

Fig 192A —Rapidly progressing tuberculous pneumonia In dian woman first examination postero anterior view The diffuse extensive irregular density in the left lower lobe is exudative and pneumonic but some areas of rarefaction in it suggest cavitation The right lung appears fairly clear

Fig 192B —Same case exactly one month later A rapidly fulminating process was present On the left side the findings have remained much the same except that the cavitation (*a*) is more obvious Meanwhile there has been extensive spread of the exudative process to the right lung with multiple cavitations (*a*) appearing here also The findings are typical of severe tuberculous pneumonia

Fig 193 —Tuberculous pneumonia with cavitation simulating lung abscess There was a history of aspiration of water into the lungs the patient having been resuscitated after near drowning The symptoms appeared shortly thereafter A diffuse density in the right lower lobe suggests pneumonia somewhat Within it a large cavity with a thick wall (*a*) and a fluid level (*b*) are visible The appearance suggests a lung abscess and the history tended to confirm it yet numerous tubercle bacilli were discovered on examination of the sputum The difficulty in distinguishing between a lung abscess and a tuberculous cavity is well illustrated The only finding which might lead to the diagnosis of tuberculosis is the extensive infiltration around the cavity Nevertheless it is often impossible to make the distinction sharply except by examination of the sputum

Fig 194 —Tuberculous pneumonia with cavitation Note the consolidation in the right upper lobe the inferior margin (*a*) corresponding sharply to the interlobar fissure between middle and upper lobes Within is a large area of rarefaction (*b*) typical of a cavity The appearance is much more suggestive of tuberculous pneumonia than that in Figure 193 because of the extent of the consolidation and the development of the cavitation In addition it should be noted that there is a cavitation (*c*) in the left upper lobe typical of tuberculosis both in situation and in character which helps to establish the diagnosis


a
a
192A
192B
b
a
c
193
194

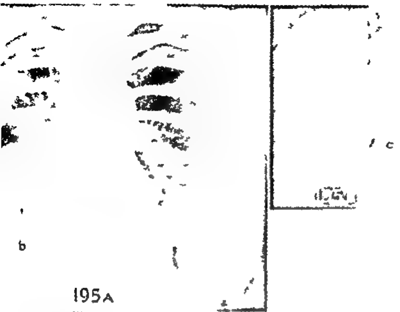
TUBERCULOUS BRONCHOSTENOSIS Tuberculous infection of the major bronchi is not uncommon With it marked secondary changes similar to those already described under bronchostenosis take place The possibility of a tuberculous etiology should always be borne in mind when atelectasis bronchiectasis or the other secondary effects of bronchostenosis are found

Fig 195A —Tuberculous bronchostenosis right lower lobe postero-anterior view *a* massive atelectasis of the right lower lobe The diaphragm is elevated and displacement of the heart (*b*) is apparent Without other evidence of tuberculosis the diagnosis would be most difficult

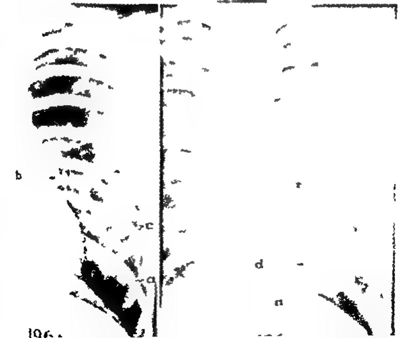
Fig 195B —Same case bronchogram right upper chest only The trachea right main bronchus and right upper lobe bronchus with its branches are well demonstrated by the contrast medium The lower lobe bronchus shows complete stenosis (*c*) This might conceivably be due to a tumor but is more suggestive of inflammation Positive sputum and the demonstration of tuberculous tissue by bronchoscopy establish the diagnosis

Fig 196A —Tuberculous bronchostenosis with atelectasis of left lower lobe postero anterior view left side only This roentgenogram was made during routine examination because of a positive tuberculin skin reaction *a* calcified focus of first infection tuberculosis *b* calcified peribronchial lymph nodes Some diffuse density (*c*) is present in the parenchyma of the lung the exact nature of which is not clearly apparent

Fig 196B —Same case 13 months later Some minor symptoms had appeared in the interim but the roentgen findings had changed to a remarkable degree Note the apparent disappearance of the calcified tubercle shown in Figure 196A Further studies showed it to be at *a* in this film A new shadow (*d*) has appeared overlapping the heart characteristic of the margin of an atelectatic left lower lobe Bronchostenosis had supervened in the interval between the two examinations with collapse of the left lower lobe Both the lung focus and the lymph nodes have moved medially and are lost within the shadow of the heart and the atelectatic lung Tuberculous granulation of the left lower bronchus was found on bronchoscopy



195A

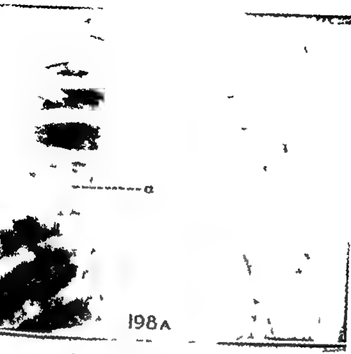


196A

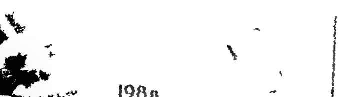
PROGRESSION OF TUBERCULOSIS Both progression and regression of the process may well be delineated by repeated roentgen examination. Comparative examinations may give considerable objective evidence of the stability or instability of the process and the progress made as the result of therapy. Despite such evidence the diagnosis of stability or of activity from the roentgenogram alone is fraught with error. The determination of activity requires repeated x-ray examinations together with all the clinical and bacteriologic evidence possible. Careful comparisons of all areas of a film should be made with similar films made previously. For this reason it is imperative to preserve a uniform x-ray technic because sharp differences in the degree of exposure may cause disappearance or accentuation of shadows without any real change having occurred. Spread of the disease to neighboring lobes or to the opposite lung can thus be determined. It is particularly important to observe closely the medial portion of the lung in the region of the hilus because new lesions often develop in the apex of the lower lobe located there.

Fig. 198A.—Pulmonary tuberculosis, exudative, with conspicuous progression of untreated lesion, postero-anterior view. First examination: a somewhat rounded area of consolidation in the middle portion of the right lung at the base of the upper lobe. It does not appear to be an extremely serious lesion although obviously exudative. It could well be simulated by an ordinary bronchopneumonia.

Fig. 198B.—Same case two years later. Note the striking progression from the small lesion (Fig. 198A, *a*) into an extensive consolidation involving most of the right upper lobe with beginning cavitation in the apex. The left lung has remained relatively free throughout the course, although in most cases of tuberculosis the other lung becomes involved rather rapidly in such circumstances. There is a small area of infiltration in the medial portion of the left first interspace.



198A



198B

MILIARY TUBERCULOSIS Acute miliary tuberculosis may cause no x ray changes for as long as six weeks after onset of symptoms The degree of roentgenologic change depends on the number of miliary tubercles which must be rather considerable before their shadows become distinctive However the changes appear much more rapidly than in the ordinary type of inspired tuberculosis because a blood borne infection develops so swiftly

Fig 201 —Acute generalized miliary tuberculosis in an adult, 10 days after onset of symptoms postero anterior view Note the fine rather uniform, homogeneous distribution of miliary nodular densities throughout both lungs from apex to base There are no local areas of infiltration the process being very acute and the original focus exceedingly small This is a fairly characteristic picture of acute miliary tuberculosis Comparison should be made with other lesions producing acute miliary processes in the lungs including pulmonary congestion and edema (Fig 34 p 93 and Fig 35 p 95) acute bronchiolitis (Figs 67 and 68 p 127) chronic bronchiolitis (Fig 105 p 157) siderosis and silicosis (Fig 136 p 187 Fig 138 p 189 and Fig 139 p 191) and miliary carcinomatous metastasis (Fig 253 p 305) The changes here are similar to those seen in acute miliary tuberculosis in childhood (cf Fig 165 p 219 and Fig 200 p 249) and sarcoidosis of the miliary type (Fig 160 p 209) They also resemble somewhat those seen in disseminated tuberculosis of bronchogenic origin (Fig 199 p 249)

Definite distinction from the other lesions is not entirely possible from the x ray examination The nontuberculous miliary lesions are usually larger not as homogeneously distributed a good deal coarser and show greater changes in character over a period of time

201

MULTIPLE CALCIFICATIONS Not infrequently symptomless individuals are found on x ray examination to have multiple small densities scattered rather uniformly throughout both lungs They vary in size number and distribution Almost invariably there are associated calcifications in the peritracheal or peribronchial lymph nodes Many theories have been promulgated as to the cause of these lesions Among the various etiologic factors suggested are fungus infections silicosis, sarcoidosis healed generalized miliary tuberculosis and finally miliary tuberculosis disseminated only into the lesser circulation during the first infection stage of tuberculosis Until recently the last seemed to be the most acceptable explanation Skin testing with tuberculin and histoplasmin has led to the strong suspicion that such calcified lesions as well as more local ones might be the result of histoplasmosis In any event the findings are usually of little clinical significance the patients rarely have symptoms nor do they show later effects In two cases acute bronchiolitis of virus origin has been observed to eventuate in multiple miliary calcifications

Fig 202—Miliary calcifications in both lungs found during routine examination Note the small dense shadows uniformly distributed in much the same manner as in acute miliary tuberculosis They differ from ordinary tuberculosis in density and discreteness of the individual nodules Some calcifications can be made out in the peribronchial lymph nodes on the right, but they are not entirely definite The patient had no symptoms and has been perfectly well since this examination

Fig 203—Multiple calcifications in both lungs Note the numerous densities scattered throughout both lungs These are somewhat larger and more variable in size than those in Figure 202 but are uniformly distributed This appearance is quite characteristic of the type of lesion thought to be due to dissemination of a first infection tuberculosis through the pulmonary circulation with eventual healing or to histoplasmosis. Note the calcified peritracheal lymph node (*a*) and the calcified peribronchial lymph nodes (*b*) similar to those seen in first infection tuberculosis

202

Fig 204 —Calcified and fibroid tuberculosis illustrating heal ing. The patient had developed tuberculosis many years before and was symptomless at the time of this examination *b* calcified peribronchial lymph nodes *c* multiple large irregular shadow of density indicating calcium *d* fibrotic bands in both the ape and the subclavicular area A similar process is present on th left side and there are numerous other areas of calcification an fibrotic strands throughout This is fairly typical of the lesion of reinfection tuberculosis when healing takes place Note th presence of emphysema the diaphragms being somewhat de pressed This often accompanies fibroid tuberculosis Note al the marked elevation of the root shadows on both sides partic larly well shown on the left (*f*) caused by retraction of the uppe lobes from scar formation Such retraction of the roots of the lun is probably related to the development of emphysema

Fig 205 —Calcified tuberculosis in an adult *a* calcified per tracheal lymph nodes *b* calcified peribronchial lymph node *c* calcified nodules in the apex of the lung on the right and the subclavicular region on the left denoting healed parenchym lesions *e* calcified cervical lymph nodes from old tuberculos also healed The findings are typical of multiple tuberculous l sions which have healed with calcification and relatively litt fibrosis This patient had no symptoms

Tuberculoma a form of tuberculosis in a more or less heal stage produces a nodular, often solitary shadow in the lun Calcification when present may help to establish its identi particularly if it is an irregular or ringlike type Otherwise su shadows may be impossible to distinguish from other granulom and tumors such as hamartoma particularly solitary metasta and peripheral bronchogenic carcinoma or alveolar cell c cinoma At times extirpation with microscopic examination advisable

204

TUMORS OF THE LUNG Insidious in onset and causing few or no physical disturbances and no abnormal physical signs in the early stages primary lung tumors must be discovered by x ray examination In almost all cases the evidences of an abnormality are present in the roentgenogram before the onset of symptoms Such findings may be minimal and are often overlooked being considered the result of previous inflammatory processes or normal variations But the detection of carcinoma of the lung at an early operable stage necessitates careful attention to all such minimal changes In some cases the x ray evidences of disease will precede the onset of symptoms by periods of many years Cases in which symptoms are present without changes in the roentgenogram are rare But the specific diagnosis of a primary tumor of the lung is not always possible from roentgen examination alone A definitive identification often requires the use of many other methods Metastatic tumors invariably give x ray evidences of their presence long before there are any symptoms or physical signs Furthermore the findings are usually so characteristic that the nature of the process can be identified

To discover and localize intrapulmonary tumors x ray examination in many positions is necessary To distinguish lesions of the chest wall from those arising in the lungs and mediastinum such detailed examination is imperative In addition fluoroscopy and roentgenography in both expiration and inspiration body section roentgenography and bronchography should be undertaken particularly for purposes of identification of the nature of the lesion Studies of the pulmonary blood vessels by injection of contrast mediums may also be used

Primary tumors of the lung whether benign or malignant are generally bronchogenic in origin Alveolar cell carcinoma and pulmonary adenomatosis also occur although very uncommon All lung tumors but especially those of bronchogenic origin, tend to imitate almost all the diseases which affect the lungs and produce a wide variety of x ray findings as follows

1 The tumor may be visible as a peripheral area of density usually sharply defined, dense, homogeneous varying in size according to its stage of development Occasionally the margins a

radiating and irregular. Such peripheral nodular lesions are most frequently discovered on routine examination, rarely causing symptoms when small. Tumors as small as 3 mm. have been detected. They are exceedingly difficult to distinguish from other processes producing similar small densities in the lung field, such as solitary metastatic tumors, hamartomas and other benign tumors, the rare peripheral benign adenomas, fibrosed or fluid filled small cysts and granulomas of varying etiology.

2. The tumor may manifest itself as a central area of density in or around the hilus of the lung, usually with radiating outer border. Unilateral enlargement of the hilus shadow is one of the common early signs of bronchogenic carcinoma and is often overlooked on routine examination.

3. The tumor may be infiltrating, producing linear streaked shadows following the vascular trunks, or faint patchy, poorly defined areas of density.

4. The tumor may arise in the apex of the lung (Pancoast or pulmonary sulcus tumor) and produce a solid or infiltrating density usually associated with erosion of the posterior portion of one of the upper three ribs or even of the lateral margin of the spine.

5. Changes similar to those of inflammation, such as abscesses and diffuse consolidations, may be caused by necrosis of the tumor and secondary infection. Occasionally the first manifestation of bronchogenic carcinoma may be a solitary cavity simulating a simple abscess.

6. Bronchial obstruction occurs early, especially when the tumor arises in a larger bronchus. As a result the following signs of partial or complete obstruction are observed:

a) Segmental, lobar or unilateral obstructive emphysema, best observed in expiratory roentgenograms.

b) Linear, segmental, lobar or unilateral massive atelectasis.

c) Drowned lung, that is, atelectasis with excessive fluid.

d) Localized bronchiectasis, especially with slow growing or ... tumors. This is much more common with benign adenoma.

e) Secondary infection producing inflammatory changes such as pneumonia, abscess, lung gangrene and carnification.

7. Metastases to the regional lymph nodes produce lobulated mediastinal densities. With body section roentgenographs and bronchography the effects of such masses on the trachea and contiguous bronchi may be seen. Examination with contrast medium in the esophagus may also delineate such masses by their pressure effects.

8. Metastases, usually nodular, sometimes miliary, rarely infiltrative, may be found in other portions of the lungs.

9. Pleural effusion develops and may obscure the tumor shadow. It is usually late and has a poor prognostic significance.

The tumor may be directly demonstrable as a positive shadow within the lumen of the air filled bronchus by body section roentgenography. Especially is this true of bronchial adenoma, but it is also an uncommon manifestation of carcinoma. A characteristic occlusion of the bronchus may be made out by either planigraphy or bronchography. In some cases the character of the obstruction is so typical that it will permit a reliable diagnosis of the tumor.

Obviously the final identification of the nature of the lesion is best made by bronchoscopy and biopsy or by the finding of characteristic tumor cells in the sputum. A final diagnosis, especially in the case of the small peripheral tumor, often requires exploratory thoracotomy with local excision and microscopic examination. When such methods are impossible the x-ray findings may suffice.

With the exception of the pulmonary sulcus tumors and a few lesions arising just under the pleura, primary carcinoma of the lung seldom produces erosion of a rib.

Multicentric alveolar cell carcinoma, as distinguished from bronchogenic tumor already described, is relatively uncommon. Pulmonary adenomatosis, although it may be a different type of process, is almost indistinguishable. Both of these lesions may begin as a solitary nodule in one lung similar to those [illegible] above. Later the lesions become multiple and often produce diffuse bilateral extensive, poorly defined, rather homogeneous dense shadows. Occasionally the tumor is so massive that it causes displacement of the mediastinum to the opposite side. It is uncommon to find cavitation or calcification within such tumors. Certain bronchographic findings which appear to be characteristic

may lead to the diagnosis Usually identification must be made by microscopic examination of the tissue

Sarcoma and teratoma of the lung also produce massive homogeneous dense shadows and frequently displace the mediastinum to the opposite side In contrast to carcinoma both of these tumors commonly involve the ribs and the erosion can be distinguished in heavily exposed films made with the Bucky diaphragm A teratoma also is likely to exhibit calcification or other irregular dense shadows within itself

Metastases produce shadows of characteristic form Whatever their origin carcinomatous metastases are likely to produce some of the following findings

1 Small round irregular multiple dense shadows which rapidly increase in size and number Occasionally a solitary metastatic tumor is found most commonly originating from hypernephroma or carcinoma of the colon

2 An infiltrating type of tumor most common in carcinoma of the breast and stomach in which linear shadows radiate bilaterally from the roots of the lungs along the bronchovascular trunks This picture must be distinguished from radiation fibrosis which is usually unilateral and causes much more retraction of the mediastinum and elevation of the diaphragm

3 Miliary lesions producing numerous tiny nodules similar to those found in miliary tuberculosis and other conditions

4 Pleural involvement with thickening and effusion which is common

Metastases from hypernephroma may cause somewhat broader more discrete shadows resembling those of sarcoma more closely than the aforementioned types Sarcomatous metastases are manifested as discrete rounded shadows usually multiple There may also be mediastinal lymph node enlargement

Metastases from testicular tumors produce extremely large somewhat oval sharply defined shadows apparently unrelated to the lung tissue Their appearance is almost pathognomonic Metastases from chorionepithelioma cause similar changes

Lymphoblastomas may invade the lung and cause changes similar to carcinomatous metastases Less frequently they are of the infiltrating and extend typically along the lymphatics

TUMORS OF THE CHEST WALL These must be distinguished from intrathoracic tumors arising in the lungs pleura and mediastinum Such tumors of the soft tissues or bony structures have little relation to the respiratory tract and are illustrated principally for purposes of differential diagnosis

Fig 206—Massive carcinoma of breast simulating lung tumor postero anterior view slight rotation to right *a* massive density due to solid tumor in the breast A shadow of the enlarged breast extends beyond the bony thorax Physical examination and demonstration that the mass extends beyond the lungs into the chest wall indicate that it is a lesion of the soft tissues rather than of the lung The small density overlying the rib (*g*) is an artefact

Fig 207—Massive tumor of left thorax arising from a Ewing tumor of rib in a child aged 10 *a* marked area of new bone formation and increased density in anterior portion of left first rib representing original bone tumor The entire left hemithorax contains an enormous mass and is completely dense except for a few areas of destruction (*b*) The mediastinum is displaced extremely into the right thorax *c* trachea displaced to the right *d* right main bronchus *e* left main bronchus lying well within the right hemithorax *f* right border of mediastinum and heart Such massive lung tumors particularly teratomas and sarcomas cause displacement of the mediastinum

Fig 208A—Chondroma of right posterior rib simulating mediastinal tumor postero anterior view *a* mass apparently in root of right lung sharply defined simulating lymphoblastoma of the mediastinum or solid tumor of the peribronchial lymph nodes.

Fig 208B—Same case lateral view The mass (*a*) actually lies far posterior and is attached to the posterior chest wall, having no relation to the root of the lung which is well anterior to it In the mass is an area of calcification (*b*) which is characteristic of chondroma The tumor was completely removed

[Tumors of the chest wall *continued on page 267*]

206

207

208A

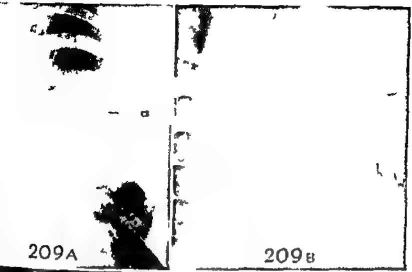
208B

Fig 209A—Sarcoma of the rib simulating a tumor in the thorax postero anterior view left chest only *a*, large dense mass apparently extending from the root of the left lung into the periphery Owing to the character of the roentgenogram the changes in the ribs are not clearly discernible

Fig 209B—Same case oblique view made with Potter Bucky diaphragm and heavy exposure *a* tumor mass *b* destruction and new bone formation involving the anterior portion of the left fourth rib from which the tumor arises Although the tumor is so large that it extends into the thorax displacing the lung away from it its origin in the rib is clearly apparent

Fig 210—Massive teratoma of the right lung and thorax with pleural effusion A massive density almost fills the right hemithorax The curving shadow of the apex (*c*) indicates the presence of some fluid which takes on this characteristic shape Most of the density is due to the mass itself A definite area of erosion of the ribs (*b*) indicates clearly the character of the tumor for carcinomas of the lung, except apical tumors rarely erode the ribs Displacement of the heart (*d*) away from the side of the lesion occurs with this type of tumor because of its massive growth

This is an example of a tumor arising within the thorax and affecting the chest wall secondarily Tumors of the pleura may also invade the ribs and soft tissues Other massive tumors of the mediastinum and lungs particularly sarcomas may have the same appearance Carcinoma of the bronchus on the contrary is seldom so massive, rarely invades the chest wall and usually causes displacement of the mediastinum toward the side of the lesion


a
209A
209B


b

Fig 211A.—Benign adenoma of the right lower lobe bronch several years after onset posteroanterior view *a* an area drowned lung involving the lower lobe The shadow merg somewhat into that of the heart but increases the density of t right cardiac border The diaphragm is only partially elevate The remaining lung is exceedingly emphysematous (*b*) In adc tion to atelectasis there is retained fluid *c* a small area of calc cation

Fig 211B.—Same case after partial removal of the tum through the bronchoscope Considerable re aeration of the lu has occurred followed by the typical bronchiectasis (*c*) oft seen with bronchial adenoma

Fig 212.—Adenoma of the left lower lobe bronchus producn massive atelectasis and drowned lung The patient's chief sym tom was hemoptysis Note the diffuse area of density in the le lower lobe with retraction of the mediastinum and elevation the diaphragm Chronic atelectasis especially when accompanie by hemoptysis, should always arouse suspicion of a bronchi adenoma (*See* p 266 for detailed study of this case)

Fig 213.—Bronchial adenoma with extrabronchial mass Th patient had intermittent hemoptysis for 12 years The mass (*d* in the superior mediastinum had been present during almo the entire time Planigraphic studies revealed a well defined ma protruding into the lumen of the right main bronchus and biops from this revealed a bronchial adenoma Many bronchi adenomas produce extrabronchial masses in the mediastinu which may easily be mistaken for lymphoblastoma dermoid c other mediastinal tumors Hemoptysis should always suggest th possibility of a bronchial adenoma Further study especiall with bronchography and planigraphy may reveal the true natur of the tumor

[Bronchial tumors Benign adenoma *continued on page 266*]


c
a
211A
212
c
211B
d
213

Fig. 215A.—Bronchogenic carcinoma, rapidly growing, producing a solid mass in the periphery of the lung. *a*, tumor mass well out to the left of the mediastinum; *c*, enlarged peribronchial lymph nodes which are metastases from the primary mass; *d*, enlarged peritracheal lymph nodes, also metastatic. The tumor is visualized as a result of its own tissue mass; it has not caused bronchial obstruction. Note the normal position of the mediastinum and diaphragms.

Fig. 215*B*.—Same case, lateral view. *a*, clearly outlined tumor lying about halfway between the anterior and the posterior surface of the axillary portion of the left upper lobe. Note its central position. The shadow is fairly well demarcated, as is often the case in such peripheral carcinomas, although some irregular areas of infiltration from the margins of the tumor extend into the periphery of the lung. The density of the tumor tissue is the least common manifestation of carcinoma of the lung.

Fig. 216A.—Bronchogenic carcinoma, right middle lobe, arising centrally and extending toward the periphery; postero-anterior view. *a*, tumor producing a shadow by reason of its own tissue mass; *b*, compensatory emphysema of the neighboring lung. The diaphragm is somewhat elevated because of atelectasis in the middle lobe.

Fig. 216*B*.—Same case, oblique view. The tumor (*a*) is superimposed on the cardiac shadow, the anterior border of which is designated *f*. The right main bronchus can be made out and some obstruction of its air content is clearly seen (*e*). Contrast this with the left main bronchus, in which the air content extends well beyond the carina. The right diaphragm (*g*) is markedly elevated. The arch of the aorta (*h*) should not be mistaken for a mediastinal mass. This was a rather malignant, rapidly growing carcinoma in a patient with moderate silicosis not clearly visible in these films.

[Bronchogenic carcinoma: Tumor mass *continued on page* [illegible]0]

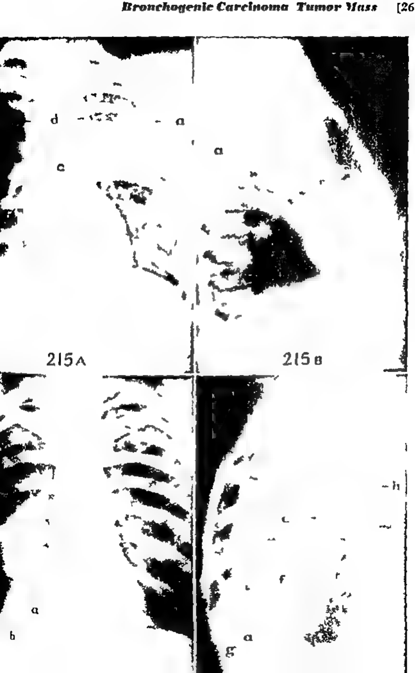

d
a
a
c
215A
215B
h
f
a
b
g
a

Fig 217 —Infiltrating bronchogenic carcinoma *a* the infil trating process showing streaked areas of density alternating with nodules apparently extending up into the apex from the root of the lung *b* a large mass corresponding to the position of the right peritracheal lymph nodes The mediastinal mass helps in distinguish this process from pulmonary tuberculosis which it strongly resembles Here again the roentgen shadows are those of the tumor itself rather than of secondary changes

Fig 218 —Bronchogenic carcinoma left upper lobe *a* cen tral tumor mass extending from the root of the lung toward the periphery characteristic of carcinoma The borders are not sharply defined but radiate into the lung tissue A deformity of the ribs is present but this is congenital and has no significance with regard to the tumor This case is another example of direct visualization of the tumor mass produced by some types of bron chogenic carcinoma

Fig 219A —Carcinoma of left apex (Pancoast or pulmonary sulcus tumor) postero anterior view portion of the left upper lobe only The patient had Horner s syndrome The left apex is completely blocked out by the tumor (*a*) In an ordinary film of this type the changes in the ribs are not clearly apparent and detailed films made with the Potter Bucky diaphragm are neces sary to exhibit such changes

Fig 219B —Same case detail film of ribs The first rib (*c*) is extensively eroded owing to compression of the tumor There is also slight erosion of the posterior portion of the second rib (*d*) This is common in the pulmonary sulcus tumor and helps to identify it


b
217
219 A
d
a

Fig 221A —Carcinoma right upper lobe bronchus postero-anterior view The patient had hemoptysis and moderate loss of weight beginning four months before this examination A dense somewhat linear shadow extending from the root of the right lung toward the periphery corresponds reasonably well to the inferior portion of the right upper lobe The shadow is dense and it is difficult on the basis of this film alone to determine how much is due to tumor and how much to atelectasis The elevated position of the interlobar fissure suggests that some atelectasis has occurred From such a film alone determination of the cause of the shadow is hardly possible although the mass in the right hilus suggests a tumor

Fig 221B —Same case lateral view *a* atelectasis of the inferior portion of the right upper lobe more clearly defined The exaggerated upward curve of the inferior border (*a*) is characteristic of atelectasis The upper two thirds of the lobe however are still well aerated This is one of the earliest stages of the obstructive phenomena associated with bronchogenic carcinoma

Fig 221C —Same case bronchogram portion of the right upper lobe *b* defect in the right main bronchus just at the orifice of the upper lobe clearly visualized It is rounded fairly sharply defined and therefore suggests a bronchial adenoma Biopsy however proved this tumor to be a carcinoma *c* trachea *d* right lower lobe bronchus which is not invaded by the tumor *e* esophagus partly filled with iodized oil The atelectatic portion of the upper lobe is seen peripheral to the tumor

The tumor in the bronchus was seen in body section roentgenograms as well


221A
a
a
b
d
e
221C

Fig 222A — Carcinoma right middle lobe bronchus with marked atelectasis postero anterior view *a* diffuse density involving the right middle lobe clearly seen This is due to atelectasis rather than to the tumor The shadow in the middle lobe merges with that of the heart which is characteristic of middle lobe atelectasis Note the clarity of the lung below this density at the periphery (*b*) indicating that the lower lobe is emphysematous in compensation The diaphragm is not elevated owing to the compensatory emphysema

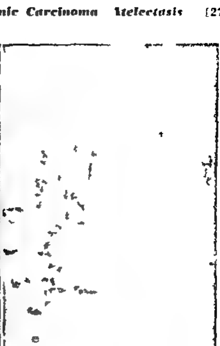
Fig 222B — Same case lateral view after instillation of iodized oil *a* the atelectatic middle lobe shrunken to about one third its normal size Despite shrinkage the borders are somewhat convex, probably owing to pleural adhesions Some iodized oil remains in the alveoli and peripheral bronchi of the lower lobe (*c*)

Fig 223 — Bronchogenic carcinoma with beginning atelectasis *a* area of density with irregular borders increasing the density of the heart and obviously lying behind it representing atelectasis of the right lower lobe The diaphragm on this side is somewhat elevated and the heart is pulled over to the right *d* enlarged peritracheal lymph nodes The patient had a history of hemoptysis for two months but no other symptoms The tentative clinical diagnosis was tuberculosis The findings here strongly suggest carcinoma of the bronchus Bronchography disclosed complete obstruction of the right lower lobe bronchus below the middle lobe branch Carcinoma was proved by biopsy

Fig 224 — Bronchogenic carcinoma atelectasis of right upper lobe right lateral view *c* margins of the right upper lobe They are elevated far above their normal position and illustrate well the type of atelectasis often seen in the upper lobe which may contract much in the fashion of a fan the anterior inferior portion extending upward and the posterior margins extending anteriorly

[Bronchogenic carcinoma Atelectasis *continued on page 278*]

222A



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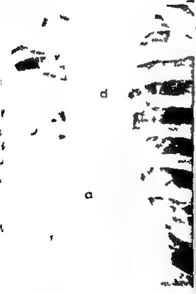

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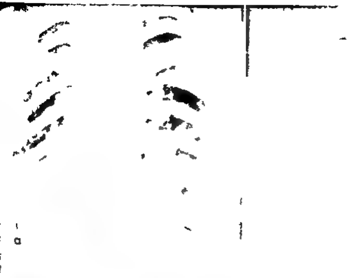
Fig 225A—Carcinoma right lower lobe bronchus postero-anterior view There is marked atelectasis of the entire right middle and lower lobes with depression of the upper border of the lower lobe (*a*) The shape of this paravertebral triangle is similar to that seen with other types of bronchial obstruction

Fig 225B—Same case body section roentgenogram *b* complete obstruction of the right lower lobe bronchus just beyond the upper lobe No air can be seen beyond this point The trachea (*c*) and first portion of the right upper lobe bronchus (*d*) are filled with air Such a planigraphic study is exceedingly valuable because it may demonstrate the obstruction without bronchography The instillation of contrast medium into the bronchus may thus be avoided

Fig 226—Bronchogenic carcinoma left upper lobe with atelectasis left lateral view This view demonstrates the type of shadow which results from atelectasis of the left upper lobe especially when there is a good deal of drowned lung The borders of the left upper lobe (*a*) are curved inward a characteristic of atelectasis and the lobe as a whole is somewhat reduced in size The posterior border of the heart (*b*) can be seen behind the atelectatic lobe The lower lobe has expanded considerably Often in such instances the lower lobe extends above the superior margin of the upper lobe coming to form the apex of the lung As the upper lobe shrinks the lower lobe may also extend to reach the anterior chest wall



225A 225B

Fig 227A —Carcinoma right upper lobe bronchus postero-anterior view Extensive atelectasis of the right upper lobe is shown by the high position of the interlobar fissure (*a*) and the extreme density of the lobe The diaphragm is considerably elevated and the trachea is slightly displaced to the right. The left lung and the right lower and middle lobes are more radiable than normal as a result of compensatory emphysema Below the border of the right upper lobe is a mass (*b*) which represents the tumor and enlarged peribronchial lymph nodes

Fig 227B —Same case bronchography portion of the right side The characteristic bronchial deformity which occurs with carcinoma can be demonstrated with iodized oil and is well illustrated here *a* lower margin of the upper lobe shown as in Figure 227A *c* completely obstructed right upper lobe bronchus The end of the bronchus is typically cone-shaped Note that the right lower and middle lobe bronchi are well filled out beyond this and the left main bronchus can also be seen

Fig 228 —Bronchogenic carcinoma bronchogram portion of right side Marked atelectasis of the right upper lobe was seen in the original film In the bronchogram a characteristic defect (*d*) is seen in the right main bronchus just distal to the carina and covering the orifice of the upper lobe bronchus Some of the oil passes beyond the defect to fill the right lower lobe bronchus (*e*) but this bronchus is somewhat dilated owing to the long standing partial obstruction which caused some bronchiectasis The defect shown here is characteristic but is not commonly seen in bronchogenic carcinoma in as typical a fashion It is somewhat more irregular than that shown in Figure 221C (p 275) and is likely to be mistaken for bronchial adenoma Nevertheless bronchoscopic biopsy is necessary to make the diagnosis final *f* iodized oil in the esophagus

227A

227B

228

INFLAMMATORY CHANGES WITH CARCINOMA

Not infrequently bronchogenic carcinoma manifests itself as an abscess or as a diffuse inflammatory process resembling unresolved pneumonia. The demonstration of an expanding mass or an unusually thick wall around such an abscess may help to identify the process.

Fig. 229.—Carcinoma right upper lobe with abscess. The patient was a woman with no symptoms except hemoptysis and moderate cough. A mass can be made out in the right upper lobe. The ragged irregular rarefaction (*a*) within it is typical of a cavity. The appearance resembles a lung abscess in some respects but there is little fluid shown in the cavity. A striking feature of the condition and one usually found in a carcinomatous abscess is the bulging shadow (*b*) extending well beyond the margins of the general mass. This indicates a growing process that would not occur in an ordinary lung abscess.

Fig. 230.—Carcinoma right lung, with diffuse inflammatory changes and multiple abscesses. Note the widespread irregular density in the middle portion of the right lung involving all of the lobes. Within it are several areas (*a*) suggesting abscess formation. There is some compensatory emphysema in the rest of the lung. The diaphragm is somewhat elevated. The heart is pulled over indicating atelectasis as well as lung destruction. The distinction between this type of process and unresolved pneumonia with multiple abscesses or multiple abscesses of the lung of other origins is sometimes very difficult. Repeated examinations to observe increase in the process, bronchography or planigraphs to demonstrate bronchial obstruction or the observation of enlargement of the mediastinal lymph nodes all suggest the neoplastic nature of the lesion.

229

Fig 231A—Bronchogenic carcinoma with abscess postero-anterior view The patient was a miner with moderate silicosis *a* large area of rarefaction which at times showed a definite fluid level within it Extending beyond it toward the periphery of the lung is a large infiltrating mass (*b*) which seems to extend directly into the chest wall Note the peripheral position of this process without any particular evidence of involvement of the root of the lung or of the medial portion of the lung

Fig 231*b*—Same case body section roentgenogram The large mass is well made out and the extension into the ribs can be clearly ascertained *a* the cavity The air filled bronchial tree is shown and the obstruction in the right upper lobe bronchus is indicated by the abrupt ending of the air column (*c*) Although the obstruction was actually incomplete the planigram as it often does gives the impression of complete closure *d* air filled lower lobe bronchus Surgery disclosed the carcinoma with abscess within it as described Definite involvement of the ribs and pleura at the periphery made complete extirpation impossible although pneumonectomy was done It is rather unusual to find so much extension to the chest wall

Fig 232—Bronchogenic carcinoma right upper lobe bronchus body section roentgenogram *a* multiple bronchiectatic and abscess cavities within the atelectatic upper lobe associated with carcinoma *b* inferior margin of the atelectatic upper lobe showing its high position and concave shape *c*, completely obstructed right upper lobe bronchus barely made out in the planigram *d* air filled lower lobe bronchus well demonstrated The diagnosis was proved by bronchoscopic biopsy and pneumonectomy was done The value of body section roentgenography as a substitute for bronchography is again demonstrated in this case

231 A

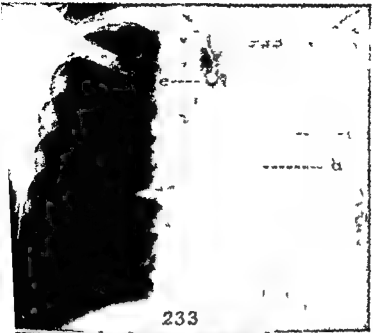
231 B

232

Fig. 233.—Carcinoma, left main bronchus, bronchogram. *a*, obstruction of the left main bronchus assuming a cap shape. Obstruction appears to be complete although some air may get through since there is some aeration of the apex of the lung. *b*, diffuse density of the atelectatic left lung. *c*, some air remaining in the apex. *d*, elevated left diaphragm. *e*, trachea pulled markedly to the left. The heart shadow is entirely in the left chest, increasing the apparent density of the atelectatic lung. This picture is characteristic of massive atelectasis of almost the entire lung associated with bronchogenic carcinoma. Demonstration of the tumor itself obstructing the bronchus was accomplished by means of bronchography. Carcinoma was proved at autopsy.

Fig. 234.—Multicentric alveolar cell carcinoma, both lungs, bronchogram. The microscopic sections were originally interpreted as infiltrating carcinoma, but further study indicates clearly the alveolar cell origin. Bronchography disclosed a striking and unusual picture. There are diffuse irregular densities of both lungs with a good deal of atelectasis on the left side. Many of the smaller bronchi are obviously surrounded by tumor tissue and extremely constricted. They are rigid and it is notable that there is a marked lack of alveolar filling. Such bronchographic findings appear to be characteristic of alveolar cell carcinoma. The condition is present on both sides and is quite uniform in this case. The larger bronchi cannot be made out because of the obstruction, but enough contrast medium has passed through them to visualize these constricted bronchi of the third and fourth order. A considerable amount of contrast medium was introduced and some of it swallowed (*f*).

The same bronchographic appearance no doubt would be produced by pulmonary adenomatosis, which is difficult to differentiate from alveolar cell carcinoma. It is possible that a similar appearance would be produced in benign adenomatosis or alveolar epithelialization, so-called jigzickte.



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The demonstration of bronchogenic carcinoma at an early stage may be difficult Occasionally during routine fluoroscopy or radiographs of the chest small tumors are discovered in apparently symptomless individuals In mass surveys of the chest for tuberculosis such neoplasms may be uncovered in an early stage

Fig 235A—Carcinoma root of right lung very early stage postero anterior view a enlargement of the hilus of the right lung with irregular radiating margins There is some emphysema of the left lung of nonspecific origin

Fig 235B—Same case lateral view The enlarged hilus (a) is clearly visible as well as the extension into the right lower lobe posteriorly (a) This was a carcinoma at a very early stage discovered by routine examination before the patient had any symptoms

Fig 236A—Postero anterior view in an apparently well individual without pulmonary symptoms The left hilus (a) is definitely enlarged as compared to the right (b) the left upper lobe shows distinct emphysema the blood vessels being spread farther apart and appearing less visible than normal the radiability of this lobe is distinctly greater than that of the other lobes on either side The condition was not recognized at the time but it is evident that this is an early stage of bronchogenic carcinoma in which there is partial obstruction of the left upper lobe bronchus and a peribronchial mass

Fig 236B—Same patient five months later Mass (a) in the left hilus has increased in size There is now complete atelectasis of the left upper lobe since the obstruction in the bronchus from the tumor has become complete The apex of the lung (c) is formed by the expanded lower lobe The patient was operated on at this time and a completely obstructive carcinoma of the left upper lobe bronchus with a peribronchial extension was found


a
a
235A
235B
b
a
a
236A
236B

Fig 237A—Alveolar cell carcinoma of the left upper lobe showing development of a solitary nodule A small nodular lesion (*a*) was overlooked at examination elsewhere The patient was symptomless the examination being entirely routine

Fig 237B—Same patient still symptomless one year later showing the growth of the nodule in the lung (*a*) Bronchoscopic and bronchographic findings are of no avail in such small peripheral lesions In this case the sputum was also negative The change in appearance of the lesion in one year is the best evidence of the malignant nature of the process On left upper lobe lobectomy alveolar cell carcinoma was found

Fig 237-1—Squamous cell carcinoma producing peripheral nodule The faint somewhat irregular density in the midportion of the right lung (*a*) was found on routine examination of a patient without pulmonary symptoms Cerebral signs however were already present and these were proved eventually to be due to a metastasis from this small carcinoma of the lung Note the irregular outline of the solitary nodule (*a*) Such nodules should be considered malignant until proved otherwise

Fig 237-2—Somewhat lobulated solitary nodule (*a*) in the left lung characteristic of peripheral carcinoma Such shadows are frequently found during mass surveys of apparently well people and should be given serious attention The patient whose roentgenogram is shown here was also symptomless It proved to be an adenocarcinoma

237-2

Fig 237-3.—Solitary metastasis (*a*) presenting a rounded, sharply defined nodule. On planigraphy no calcium could be seen within it. A history of carcinoma of the colon however led to the diagnosis of solitary metastasis which was proved later by segmental pneumonectomy. It is impossible to distinguish such solitary nodules from many other nonmalignant lesions or from an early alveolar cell or bronchogenic carcinoma of the lung.

Fig 237-4.—Hamartoma of the lung. A round somewhat sharply defined dense shadow (*a*) characteristic of many nodular lesions of the lungs, often the exact nature of the pathologic process cannot be determined until biopsy and microscopic examination. In some hamartomas stippled calcium deposits can be made out especially with planigraphy. In others the calcium cannot be demonstrated even with planigraphy.

Fig 237-5.—Cyst of the lung completely solid from fibrosis. A round sharply defined nodule (*a*) very similar to other types and causing no symptoms or other signs. Such nodules are extremely difficult to distinguish from granulomas. (*Compare with* the tuberculomas shown in Figs 167 and 181.)

Fig 237-6.—Extrabronchial adenoma or mixed cell tumor of the bronchus apparently nonmalignant. The patient had occasional hemoptysis but no other symptoms. A somewhat oval dense mass (*a*) showed evidences of calcification within it leading to the thought that this was either a tuberculoma or hamartoma. On extirpation however it proved to be a mixed tumor of the bronchus with an extrabronchial mass. Calcification is rare in such tumors but even more rare in the carcinoma of the lung. The absence of calcification in the latter may be helpful in differential diagnosis. (*Compare with* Figs 167B and 213.)

237 3

237 4

237 5

237 6

Fig. 244.—Tuberculoma simulating metastasis. Not infrequently a single nodular lesion closely resembling metastasis is found in the lung. When only a single lesion is found, as in this case, diagnosis must be made with great reserve. The sharply defined nodule (*a*) resembles metastatic nodules previously reported and others in this series but was proved to be a tuberculoma. This possibility must always be considered. Metastases are rarely single.

Fig. 245.—Nodular metastases from carcinoma of the breast. Numerous dense shadows (*a*) can be fairly well made out in both lungs. They are not as sharply defined or as round and regular as those usually found in metastases from sarcoma and testicular tumors. Absence of a breast shadow causes the increased radiability of the left hemithorax and gives the clue to diagnosis.

Fig. 246.—Metastases from carcinoma of the kidney (hypernephroma). In this type of lesion the nodules (*a*) are likely to be rather sharply defined and dense, simulating those of sarcoma, although in many instances the lesion is indistinguishable from metastases from carcinoma in other organs.

Fig. 247.—Metastases from carcinoma of the kidney (hypernephroma). A tremendous number of nodular densities fills both lungs from apex to base. The shadows merge into each other. Numerous metastases of this kind are not rare and it is surprising to find how few symptoms a patient with so much involvement of the lungs may have. Physical signs also may be almost entirely absent. The lesion here is characterized by its nodular form, the variation in size of the nodules, the absence of any infiltrative process and a rather uniform distribution.

[Pulmonary metastases, Nodular *continued on page 300*]

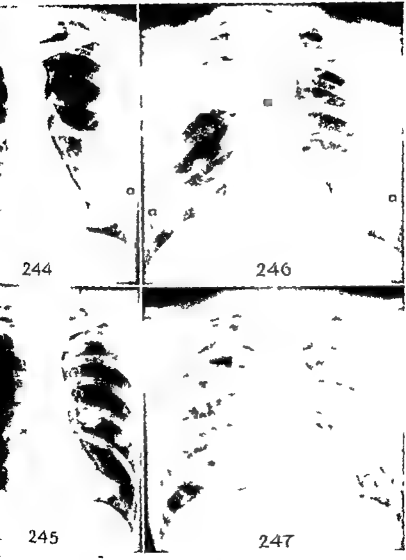
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Fig 218 — Nodular metastases from carcinoma of the breast, early stage Only two small nodules (*a*) can be made out distinctly although there are a number of others not as well reproduced Despite their small size and number they are so characteristic that a definite diagnosis can practically be made from the roentgenogram alone Note the increased radiability of the right lung owing to absence of the right breast which had been removed surgically

Fig 219 — Miliary metastases from primary carcinoma of the right lung The changes are well illustrated in the left lung where numerous miliary nodules are readily made out These should be compared with other miliary lesions in the lungs mentioned in the discussion of Figure 201 (p 250) The primary tumor is on the right side there is some pleural effusion as well The density designated *b* is an artefact Such miliary lesions are not rare in carcinoma especially from one originating in the lung They can be distinguished by the relative absence of symptoms in proportion to the lung involvement and by visualization of the primary tumor In many instances however although the lesions can be detected by roentgen examination identification must be made by other means or by re-examination to determine progression or regression

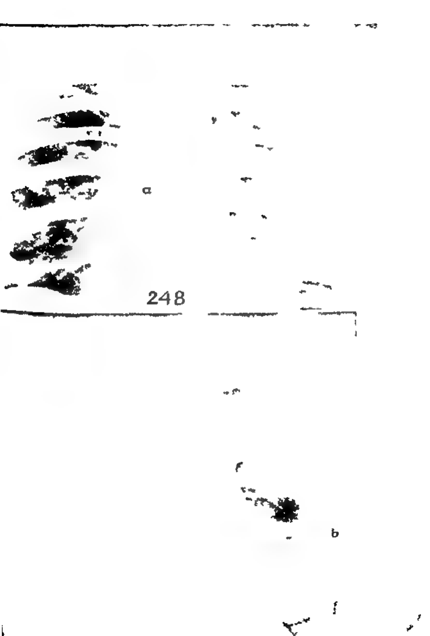

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Fig 250 —Metastases from carcinoma of the prostate Metastases from prostatic tumors are not often seen in the lungs The tend to cause multiple nodular dense areas such as those see here They do not differ sharply from the metastases of othe types of carcinoma

Fig 251 —Infiltrating and nodular carcinomatous metastase lymphogenous type The primary source was a carcinoma of th breast in a male *a* nodular type of metastasis Numerous simil lesions are present particularly well shown at the right bas *b* infiltrating lesions extending into the periphery of the lung The lymphogenous spread produces linear radiating shadow suggesting an accentuation of the normal vascular markings Th shadows are the result of perilymphatic infiltration by tumor tis suc c enlarged root shadows bilaterally involved and charac teristic of this type of carcinomatous metastasis The symmetrica character the absence of conspicuous retraction of the medias tinum and diaphragms the generalized infiltration and the nod ules distinguish this from radiation fibrosis and other types of non malignant fibrosis of the lungs *d* azygos lobe fissure an an atomic variant


250

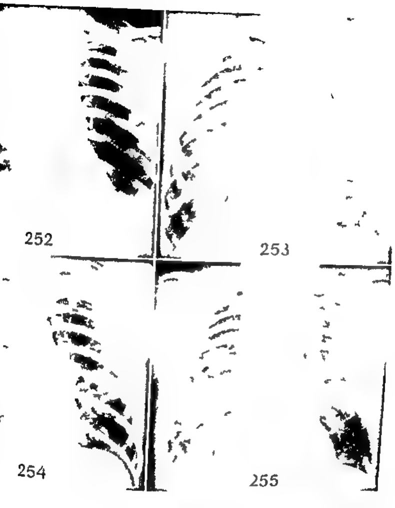

d
b
c

Fig 252 —Hodgkins disease of lung massive density of the right upper and middle lobes There is actual infiltration of the lung parenchyma by the process Associated with it is some atelectasis Note the minimal pleural effusion on the left side

Fig 253 —Infiltrating Hodgkins disease both lungs Note the markedly enlarged hilus shadows and the diffuse radiating lines of increased density extending into the lungs It would be difficult to distinguish this process from a metastatic infiltrating carcinoma (see Fig 231 p 303) or from primary lymphogenous carcinoma of both lungs The pathology can only be demonstrated by biopsy of enlarged lymph nodes found elsewhere Radiation therapy may be used in such instances as a therapeutic test Striking rapidity of resolution usually signifies that the lesion is a lymphoblastoma

Fig 254 —Hodgkins disease both lungs and mediastinum Note the generalized infiltration and the multiple miliary nodules in both lungs The process is diffuse but in addition there is one large mass in the right middle lobe Both hilus shadows are lobulated and enlarged owing to involvement of the mediastinal lymph nodes

Fig 255 —Diffuse lymphatic leukemia both lungs Note the enlarged root shadows and the diffuse infiltrating process extending into the periphery of both lungs which is quite characteristic of the lesion From the roentgen findings alone it is difficult to distinguish leukemic infiltration from Hodgkins disease and infiltrating carcinoma Leukemia produces a more uniform generalized process



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THE MEDIASTINUM The central shadow of the thorax is composed of the heart aorta root shadows of the lungs remaining large vessels trachea and larger bronchi Mediastinal abnormalities are manifested by changes in width shape and density of the central shadow Roentgenography and fluoroscopy in several projections are important because the heart and great vessels spine and sternum cover other shadows if viewed in only one position The lateral view is especially important for diagnosis of masses having a central position such as bronchogenic cysts and thymomas

Roentgen signs of pathologic processes in the mediastinum result from enlargement of normal structures the lymph nodes thymus thyroid aorta and esophagus development of new growths and presence of gas or fluid in the mediastinal tissues. Distinction between the mediastinal pleura and the mediastinum is essential because fluid may be found free or encysted in both the mediastinal pleural space and the mediastinum The mediastinal pleura is not visible unless displaced by a hernia from pneumothorax Air may occur in the mediastinum often associated with emphysema of the cervical tissues

Inflammation of the mediastinum may be diffuse changing the shape of the central shadow and causing external adhesions especially to the diaphragms and esophagus Fluid accumulates in the mediastinum as an abscess It usually presents a rather ill defined density often bilateral or posterior It is often associated with clinical symptoms out of all proportion to the x ray changes

Enlargement of the thymus gland is common in infants Mediolateral widening has little significance unless accompanied by evidence of tracheal compression seen in the lateral view Films should be made in both inspiration and expiration becau the normal thymus in the infant appears enlarged during expir tion and with crying Visualization of benign thymoma often a sociated with myasthenia gravis necessitates careful observati of the lateral view otherwise the shadow may not be seen

Enlarged thyroid glands often extend into the substernal r gion or lower The shadow is usually bilateral rather anteri often moves with swallowing and usually can be differentiat

from the aorta on fluoroscopic examination in various

Enlarged lymph nodes tend to give irregular lobul ows Tuberculosis has already been discussed Sarcoid ema nodosum and certain fungus diseases produce cl symmetrical sharply defined shadows in the hilus of

X ray examination is the prime method for diagn lymphoblastomas The mediastinal shadow is widened and dense unilateral in some cases especially lymph and bilateral in others including Hodgkin s disease Distinction of the three is not always possible

Mediastinal tumors are of variable origin They can be distinguished from each other by position presence cation fat or other irregular densities and relation to oth tures Certain mediastinal masses have special characteri

1 Dermoid cysts teratomas thymomas and enlarged thyroid are usually anteriorly located Lymphoblastomas tend to be in the middle or anterior mediastinum Neurofibromas are usually posteriorly located Bronchogenic and gastric cysts and thymomas lie in the midline

2 Calcification is seen in inflammatory lymph nodes dermoids and teratomas

3 Rarely a layer of fat of lesser density is seen in dermoids

4 Hodgkin s disease fibromas thymomas and enlarged thyroids are usually bilateral

5 Lymphosarcomas dermoids and neurofibromas are usually unilateral

6 Aortic aneurysm may appear in any position and is distinguished by expansile pulsation and continuity with the aorta

7 The dilated esophagus with cardiospasm gives a wavy elongated right sided density extending from the neck to the diaphragm A swallow of barium sulfate will identify it

8 Paravertebral abscess produces a fusiform bilateral density easily recognized as related to the spine

9 Neurofibromas may have associated erosions of the vertebral pedicles

Displacement and motion of the mediastinum during respiration are important evidence of pulmonary and pleural diseases

The mediastinum should be examined in various positions Often tumors or enlarged lymph nodes are seen in one position when completely hidden in another

Fig 256A—Calcified lymph nodes in mediastinum postero-anterior view of mediastinum apparently normal The principal components of the central shadow of the thorax are the heart aorta spine and hilus shadows of both lungs They are comprised largely of blood vessels and the major bronchi No abnormalities are seen

Fig 256B—Same case left oblique view The outlines of various structures are more easily visualized in this position *a* trachea *b* left main bronchus *c* arch of the aorta extending into its descending portion *d* manubrium sterni *e* body of the sternum The cartilaginous symphysis between manubrium and body of the sternum is seen as a line of lesser density *f* plaque-like area of density representing a calcified lymph node at the bifurcation Note how clearly it is seen in this position although not visible in the ordinary postero anterior roentgenogram It is probably the result of tuberculosis

Fig 257—Mediastinal emphysema following trauma *g* stripe like shadows of lesser density in the cervical region where the air has extended from the mediastinum through the posterior cervical fascia *h* similar stripelike shadows along the large vessels and even extending lower down overlying the heart These are characteristic of air in the mediastinum following rupture of the lung and extension along the bronchi

Fig 258—Diffuse mediastinitis Diffuse dense shadows along the mediastinum increase its width in a highly irregular fashion Radiating from these shadows are numerous bands of adhesions extending into the lung The trachea (*a*) is displaced somewhat to the right by retraction of the process around the mediastinum In such cases examination of the esophagus filled with barium often reveals traction diverticula and evidence of adhesions

[Mediastinum continued on page 310]

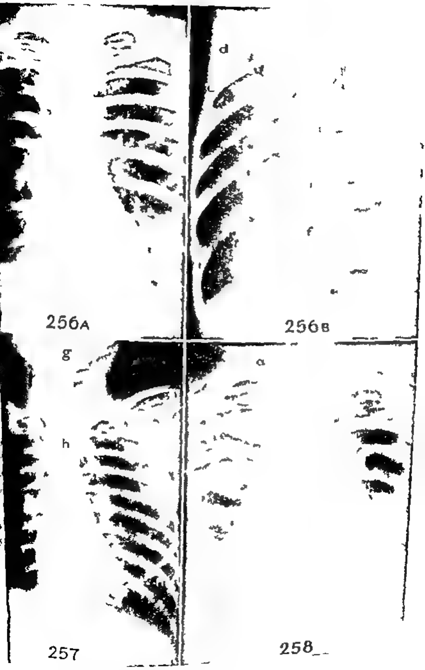
d
f
256A
256B
g
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Fig. 259A.—Mediastinal empyema, massive, postero-anterior view, supine position. *a*, large mass in the right mediastinum extending out toward the lung field. Such a mass may be produced by a variety of conditions; in this case it was due to a collection of pus in the mediastinal pleural space. A large mediastinal abscess may give a similar appearance. *b*, heart displaced to the left, which is common with large mediastinal masses.

Fig. 259B.—Same case, upright position, after withdrawal of fluid. A gas bubble can be made out within the fluid (*c*). There is still a large amount of pus in the empyema pocket.

Fig. 260.—Mediastinal hernia from pneumothorax, bilateral. *a*, displacement of the mediastinal pleura by increased pressure in the left hemithorax. The pleural shadow is visible because it is beyond the central shadow of the spine. It is important to observe such a displacement of the mediastinal pleura because it may indicate that too much pressure has been applied. *b*, cardiac shadow displaced to the right by the left pneumothorax. *d*, edge of left lung in contrast with the pneumothorax lateral to it. *d*, border of right lung in contrast with pneumothorax (*c*) on right side.

Fig. 261.—Cardiospasm with massive dilatation of the esophagus simulating mediastinal tumor, upright position. With extreme cardiospasm the esophagus may be enormously distended with food and fluid and give a distinctive shadow even though barium has not been administered. Characteristically this shadow extends up into the neck and down to the diaphragm in a fashion seldom imitated by any mediastinal tumor. *a*, right border of the shadow of the esophagus. The film was made with the patient upright so that the gas which had been swallowed could be made out above. There is a fluid level (*c*) between the gas and the fluid in the esophagus.

259A

259B

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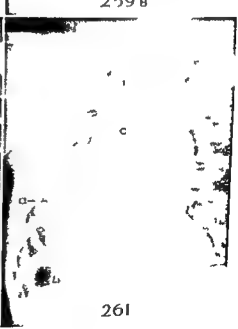

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Thymus gland enlargement can be visualized in both postero anterior and lateral roentgenograms Observation of the effect on the trachea especially in expiration is of particular importance Marked changes may occur in phases of respiration

Fig 262A —Thymus gland moderate enlargement, in an infant postero anterior view in deep inspiration Note the wide shadow of the mediastinum in its superior portion characteristic of thymus gland enlargement

Fig 262B —Roentgenogram made at same time in expiration The thymus shadow appears to be much larger than in Figure 262A In some cases simply as a result of expiration even greater differences than those shown here occur

Fig 263 —Moderate enlargement of thymus lateral view The normal shadow of the trachea (*a*) is shown in this position

Fig 264 —Enlarged thymus lateral view The trachea is distinctly compressed and the air column (*b*) is almost invisible Below the level of the thymus air can be seen entering the bronchi This is a characteristic effect of the enlarged thymus on the trachea and is particularly well shown in films made in the phase of expiration Note the shadow of the thymus lying anteriorly under the sternum

Fig 265 —Moderate enlargement of thymus postero anterior view The mediastinal shadow is wide rounded and symmetrically enlarged Note how difficult it is to distinguish the thymus from the cardiac shadow A lateral view will demonstrate the shadow lying well anterior

Fig 266 —Markedly enlarged thymus in an infant The characteristic "sail" shadow overlies the heart and extends conspicuously to the right The sharp angulation between the thymus shadow and the heart on the right is somewhat unusual Such a shadow is frequently mistaken for mediastinal tumor encapsulated mediastinal fluid or atelectasis of the upper lobe Observation of marked changes during respiration and of the extreme anterior position of the mass in the lateral view should make the distinction

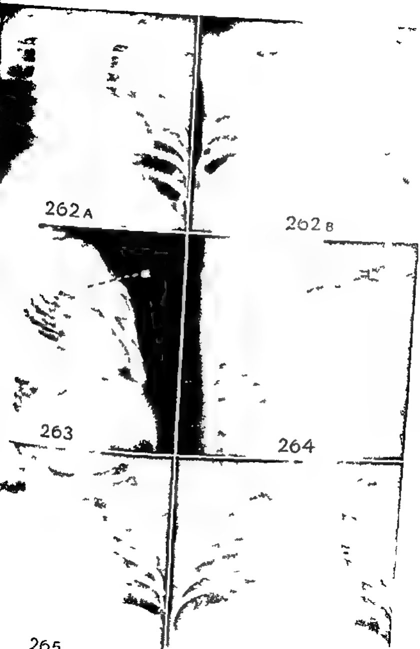
262A
262B
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Fig 278—Dermoid cyst of the mediastinum a large rounded sharply defined mass found accidentally during a routine examination It caused no symptoms The mass seems to extend somewhat up to the neck the distinction between this and a unilateral substernal goiter or fibroma of the mediastinum is extremely difficult On fluoroscopic examination in the lateral view the mass was seen in anterior position did not pulsate was separable from the aorta and did not move with swallowing all of which suggested a dermoid Operation revealed a mass composed principally of splenic tissue and some fibrous tissue and cartilage

Fig 279—Dermoid of mediastinum with characteristic fat layer An irregularly oval shaped mass (*a*) extends from the mediastinum toward the apex Surrounding this mass in the upper portion is an area of greatly increased radiability (*b*) which represents fat in the dermoid

Fig 280A—Bronchogenic cyst of mediastinum postero-anterior view The patient had no symptoms and the lesion was noted during routine examination a small rounded sharply defined mass in the central mediastinum lying close to the mid line It does not contain gas because it does not communicate with a bronchus as does a lung cyst Its position the shar outline characteristic of benignancy and the absence of symp toms suggested the diagnosis of bronchogenic cyst Gastric cyst esophageal cysts and other duplications produce similar shadow

Fig 280B—Same case body section roentgenogram Th outline of the cyst (*a*) is clearer and the slight displacement the bronchi (*c* and *d*) is well shown Note the close resemblan to Figures 275A and C (p 319)

[Mediastinum Tumors *continued on page 322*]

278

280A

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280B

Fig 281 —Fibrosarcoma of mediastinum a lobulated tumor lying in the midmediastinum and projecting both to the right and to the left This is more in the peribronchial than in the peritracheal region but in other respects closely resembles a lymphoblastoma Note the arch of the aorta (*b*) as a separat shadow Diagnostic irradiation was required to demonstrate that because of lack of response this was not a lymphoblastoma. The final diagnosis was proved by surgery

Fig 282 —Chondroma of mediastinum lateral view A large calcified irregularly shaped mass sharply defined lies in the mediastinum and projects into the posterior portion of the lung The irregular deposit of calcium within the mass helps to identify the nature of the tumor

Fig 283A —Neurofibroma of posterior mediastinum in a child postero anterior view A large well defined sharply outlined dense mass (*c*) in the right lower lobe extends behind the heart. The density of the cardiac shadow is increased by the mass

Fig 283B —Same case lateral view The posterior position of the tumor lying behind the heart (*c*) is well demonstrated The position helps to establish the diagnosis of neurofibroma

Fig 284 —Teratoma of left superior mediastinum A large dense mass extends from the mediastinum well out into the lun fields It is sharply demarcated but shows no calcification o other types of tissue The location of the mass suggests either teratoma or a sympathicoblastoma Displacement of the trache (*d*) is well demonstrated

81

282

283 B

284

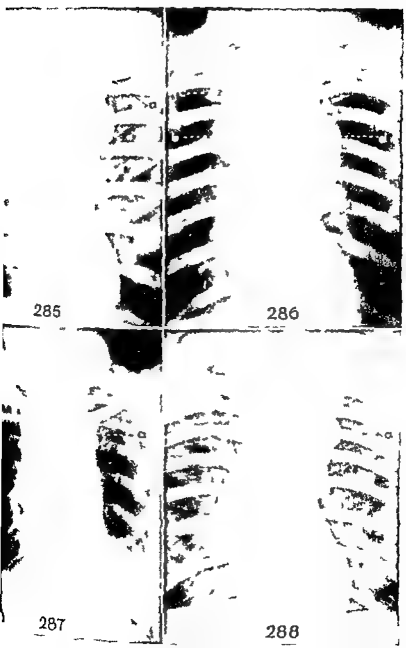
The four cases shown here illustrate the similarities and dissimilarities of various masses in the mediastinum especially in the postero anterior view Differentiation of the conditions is often exceedingly difficult because they may simulate each other closely

Fig 285—Hodgkin's disease of superior mediastinum *a* the lobulated appearance characteristic of the condition The mass lies in the superior mediastinum on both sides

Fig 286—Aneurysm of ascending aorta and innominate artery *b* aneurysmal dilatation of the ascending aorta *c* aneurysm of the innominate artery extending up toward the neck *d* dilated and displaced arch of the aorta Note the striking resemblance to the case of Hodgkin's disease shown in Figure 285 The demonstration by fluoroscopic examination in a variety of positions of pulsation in the mass and of its inseparability from the aorta aided in differential diagnosis It is not always possible however to make the distinction

Fig 287—Thyroid enlargement substernal *a* somewhat wedge shaped mass also bilateral and extending well down to widen the mediastinum This can usually be differentiated from aneurysm of the aorta by lack of pulsation motion with swallowing and definitely anterior position

Fig 288—Teratoma of mediastinum in a young adult The mass (*a*) represents a malignant teratoma This tumor is usual differentiated by its anterior position and unilaterality The presence of calcification or other solid tissue in the teratoma is helpful but is not always apparent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THE PLEURA To have an intelligent grasp of the x ray findings in pleural diseases a brief recapitulation of the pleural topography is necessary The posterior costophrenic sinus lies far below the dome of the diaphragm the anterior sinus is somewhat higher although well below the superior margin of the diaphragmatic shadow There is a large space therefore below the dome not visible in the usual upright position

It is important to observe the location and relationships of the interlobar pleural reflections For all practical purposes three fissures may be present on the right side (1) one between the upper and the lower lobe lying above and posteriorly (2) one between the upper and the middle lobe lying anteriorly and extending directly from front to back (3) one between the middle and the lower lobe lying obliquely behind and posteriorly The location of these clefts is variable so too much emphasis must not be placed on their exact relation to the overlying bony thorax The major fissure presents a long oblique surface and has little anteroposterior depth The minor or horizontal fissure is almost straight so has a deep anteroposterior diameter The fissures should be regarded as large surfaces not linear projections

The reflection of the mediastinal pleura around the heart and mediastinum and posteriorly around the spine is to be noted It communicates freely with both the peripheral pleural cavity and the fissures The mediastinal pleural cavity is separated into anterior and posterior spaces by the ligamentum pulmonale and into upper and lower spaces by the root of the lung pocketing in this portion of the pleura takes on corresponding distributions

The free suspension of the mediastinal structures in the middle of the thorax separating the lungs from each other anteriorly is an important feature of the anatomy Changes in intrapleural pressure such as occur with the accumulation of fluid or gas in either pleural cavity cause marked changes in position of the central structure unless it has been fixed by adhesions

Roentgen examination under certain conditions will reve[al] disease of the pleura in its earliest stages However many change[s] in the pleura may give no obvious roentgenologic signs For e[x]ample before the development of fluid or any particular thicken

ing of the pleura acute fibrinous pleurisy may cause few or no x ray changes except some restriction of diaphragmatic movement on the involved side Complete pleural synechia may cause no signs except some lack of motion of the diaphragm on the involved side and some loss of radiability of the entire lung

Normally the shadow of the pleura can be seen only in films taken at such an angle that the beam strikes the pleura tangentially In such circumstances the points of reflection of the pleura over the diaphragms at the interlobar fissures at the mediastinum and over the apexes can be made out The normal interlobar fissure between the upper and the middle lobe is commonly seen and also the fissures of the anomalous lobes Visualization of the major oblique fissure usually indicates thickening

Simple thickening of the pleura which occurs in various diseases will cause a shadow of the pleura at points struck tangentially by the x ray beam Thus the pleura at the periphery and in the fissures may produce a shadow With extreme thickening the entire lung on the involved side shows a marked increase in density Fluoroscopic examination reveals the diaphragm to be partially immobilized and often retracted upward the heart and trachea are displaced toward the involved side The costophrenic sinus which normally is clear is obliterated and adhesive bands are seen extending from the surface of the diaphragm

Calcification in the pleura produces a shadow denser at the periphery than over the surface of the lung

The x ray diagnosis of pleural collections is based on the contrasting shadow which fluid or gas produces when in juxtaposition to the air filled lung The fluid shadow has much the same density as that of the heart diaphragm and subdiaphragmatic organs To visualize pleural fluid contrast must be present Usually the fluid collects on only one side and may be distinguished by contrast with the normal air filled lung on the opposite side or with the portion of the involved lung which remains expanded It must be borne in mind however that there is little or no difference in the density of the shadows produced by consolidation of the lung a massive tumor marked pleural thickening and pleural fluid Furthermore there is no difference

PLEURAL THICKENING Various portions of the pleura can be demonstrated at their points of reflection even when normal when thickened the pleura becomes quite obvious provided the proper position is used

Fig 289 —*Postero anterior view* right side of the chest *a* thickened horizontal interlobar fissure between middle and upper lobes giving a double shadow because the anterior level of the fissure is not the same as the *posterior level* *b* thickened pleura with adhesions to the diaphragm and obliteration of the costophrenic angle

Fig 290 —Residual pleural thickening following pleural effusion right lateral view *a* thickened minor interlobar fissure between middle and upper lobes *c* thickened major fissure between middle and lower lobes *d* thickened pleura adherent to the elevated diaphragm The fissures have become visible because of their thickening so that they delineate the various lobes of the lung

Fig 291 —Normal reflection of pleura posterior mediastinum *e* sharply defined rather straight shadow on both sides of the spine Such lines are seen only in films made in the anteroposterior position with heavy exposure Because of the tangential projection at this point of reflection the density of the normal pleura is sufficient to give a shadow *f* Cardiac shadow

Fig 292A —Thickened interlobar fissure postero anterior view *a* diffuse rather ill defined density in the right upper region

Fig 292B —Same case moderate right oblique projection This brings out the shadow (*a*) distinctly and shows considerable thickening of the oblique fissure Films made in the position of lordosis are also useful in such instances

[Pleura Thickening *continued on page 332*]

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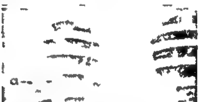

292 A

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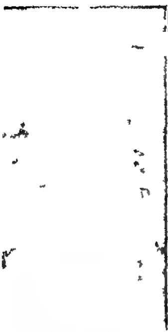
292 B

Fig 293 —Thickening of interlobar pleura postero anterior view When greatly thickened the oblique fissure (*a*) on the right side is occasionally seen even in postero anterior projections The fissure extends to the diaphragm where it apparently forms an adhesion It is visible here in its anterior inferior portion *b* shadow of a rather pronounced pectoralis major muscle

Fig 294*A* —Thickened pleura residuum of pleural effusion postero anterior view upright position The differentiation of thickened pleura from effusion in the pleural cavity is often difficult and films made with the patient in various positions may be helpful Thickened pleura (*c*) obliterating the costophrenic angle on the left side is well shown Along the periphery of the lung the pleura (*d*) is denser than normal The density (*e*) overlying the ribs is an artefact

Fig 294*B* —Same case left lateral decubitus position The densities at the costophrenic angle (*c*) and the periphery of the left lung (*d*) remain approximately the same as in the upright position indicating that this is simply thickening of the pleura rather than effusion



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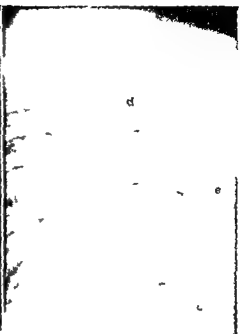


294A

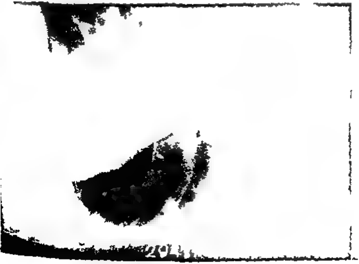
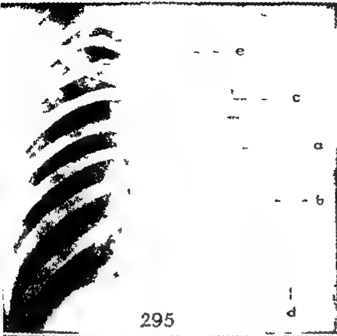


Fig 295 —Tuberculosis with long standing pneumothorax postero anterior view *a* markedly thickened pleura characteristic after a long period of pneumothorax It is much more dense at the periphery than elsewhere because the entire antero posterior diameter of the pleura is tangential here to the x ray beam *b* diffuse density of remaining portion of the lung owing to generalized thickening of the pleura both anteriorly and posteriorly *c* local area of emphysema of the lung oft n seen with thickened pleura *d* elevated diaphragm with adhesions a residuum of the same process *e* trachea retracted to the left because of lung fibrosis incident to the tuberculosis

Fig 296 —Calcification of pleura resulting from tuberculous empyema *a* outer margins of the calcified process much denser than the inner portion because the total anteroposterior thickness is struck tangentially by the x ray beam The inner portions of the calcified pleura (*b*) are stippled irregular and often linear Calcification of the pleura of this type is not uncommon following hemothorax empyema and tuberculosis



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PLEURISY WITH EFFUSION Fluid in the pleural cavity even small accumulations can be demonstrated with great accuracy on roentgen examination particularly if films in various positions are used It is important to bear in mind that in the ordinary postero anterior upright roentgenogram of the average adult 300–400 cc of fluid must be present before it is visible The lateral decubitus position facilitates the demonstration of smaller amounts of fluid

Fig 297A –Tuberculous pleurisy with effusion postero anterior view upright position *a* the first sign of effusion that is obliteration of the costophrenic angle *b* irregular, flattened diaphragm shadow owing to fluid spread over it

Fig 297B –Same case right lateral decubitus position The fluid extends out from beneath the diaphragm into the inferior costal gutter (*b*) and is therefore much more visible In this case it was perfectly evident from the ordinary view that there was an effusion In many others however small amounts of fluid that are not visible in the upright position may be diag nosed by this maneuver The horizontal interlobar fissure (*c*) is thicker than normal because in this position the fluid tends to extend into it Note that the fissure is not seen in Figure 297A

Fig 298 –Pleurisy with serous effusion postero anterior view upright position A moderate quantity of fluid is present and the typical curving shadow of pleural effusion (*a*) most common with inflammatory collections is seen Some of the fluid has ex tended into the horizontal interlobar fissure (*c*) and also into the oblique fissure (*d*) A thin layer of fluid covers the entire right side of the thorax thereby diminishing its radiability

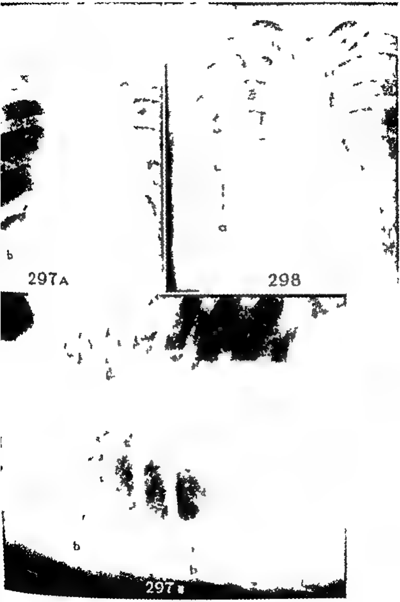
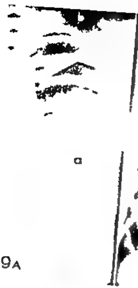

b
297A
a
298
b
b
297B

Fig 299A—Pleural effusion of tuberculous origin postero-anterior view upright position *a*, characteristic curve of the fluid *b* layer of fluid extending along the periphery of the lung and over the apex *c* heart displaced distinctly to the right because of considerable accumulation of fluid *d* calcified first infection tuberculosis of the right lung

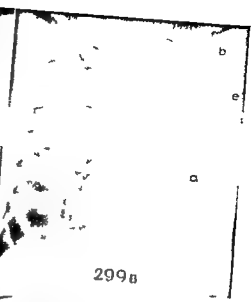
Fig 299B—Same case supine position Note change in the position of the fluid a much larger quantity now being present at the apex (*b*) while the upper level of the fluid is lower (*a*) A small amount of aerated lung (*c*) can be made out but its density is distinctly greater than that of the opposite side because of the layer of fluid which covers it anteriorly and posteriorly

Fig 300—Marked pleural effusion from cardiac failure This is a transudate and assumes a different distribution The fluid level (*a*) is much flatter although a small amount of fluid extends up by capillarity along the periphery of the lung toward the apex (*b*) The heart is distinctly displaced to the left

Fig 301—Massive pleural effusion in a child with nephrosis *c* heart displaced markedly to the right *f* trachea displaced to the right The entire left hemithorax is obliterated from apex to diaphragm Complete opacity of one hemithorax as shown here must be distinguished from a variety of conditions including massive atelectasis massive pneumonia massive tumor and chronic lung fibrosis With pleural effusion the mediastinal displacement is a most helpful sign As shown in Figure 210 (p 263) this may also occur with lung tumors and in some cases differentiation can be made only by paracentesis



299A



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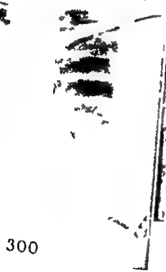

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Most pleural effusions tend to show a distinct shift when the patient is changed from upright to supine prone or decubitus position With empyema and long standing inflammatory effusions with adhesions this does not occur

Fig 302A —Postpneumonic empyema in a child upright position The ribbon like shadow at the periphery of the lung (*a*) is typical of purulent effusion Note the extension of fluid into the horizontal interlobar fissure (*b*)

Fig 302B —Same case supine position The findings are almost identical with those in Figure 302A despite the shift in the patients position

Fig 302C —Right lateral decubitus position Despite the radical shift in position the curving ribbon like shadow at the periphery (*a*) and extension into the interlobar fissure (*b*) are again seen

Fig 303A —Bilateral effusion with nephrosis in a child postero anterior view upright position *a* shadow of fluid at the periphery *b* fluid simulating elevated diaphragms The upper portions of the lungs appear relatively free The fluid assumes a position almost as if gravity were the only factor There was no pneumothorax

Fig 303B —Same case supine position There is a striking shift in the position of the fluid The diaphragm (*b*) can now be made out on the right side There is a thicker shadow of the fluid at the periphery (*a*) and some has extended over the apex (*c*)

Fig 303C —Right lateral decubitus position On the left side the fluid now lies completely behind the heart and its shadow (*e*) is merged with the cardiac shadow so that distinction is almost impossible On the right side the fluid lies in the inferior costal gutter (*a*) thus exhibiting its true quantity much better than in either of the foregoing films The heart (*d*) is dropped somewhat to the right in this position

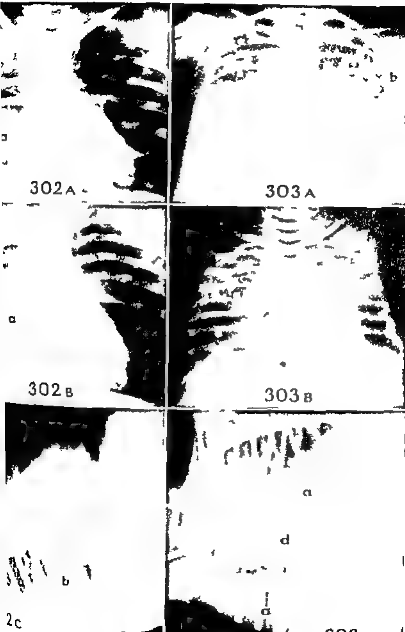
302A
303A
b
a
302B
303B
a
b
2c
a
d
a
303c

Fig 304A —Constrictive pericarditis with left sided pleural effusion postero anterior view upright position The left diaphragm (*a*) appears to be elevated Actually this shadow represents fluid adjusting itself to the inferior cupola of the lung and spreading in a layer over the diaphragm In this position it is scarcely possible to be certain that a pleural effusion is present.

Fig 304B —Same case supine position The fluid is spread in a thin layer throughout the left hemithorax The diaphragm (*b*) is now in almost normal position The entire left lung shows conspicuous decrease in radiability because of the fluid This is not an unusual finding in pleural effusions and may be exceedingly deceptive

Fig 305A —Pleural effusion from cirrhosis of liver postero anterior view upright position right side only The right diaphragm (*a*) appears to be markedly elevated Actually the shadow represents fluid spread over the diaphragm and simulating its shadow There is a questionable suggestion of fluid in the interlobar fissure on this side

Fig 305B —Roentgenogram made at the same time right lateral decubitus position The fluid extending into the inferior costal gutter (*c*) indicates presence of a large quantity The diaphragm is in normal position A large amount of fluid has extended into the major interlobar fissure (*d*) giving a rather bizarre distribution


a
304A
a
305A
c
d
305
304B
b

Encysted pockets of fluid may occupy various positions. These may be designated as axillary, mediastinal, apical, supradiaphragmatic, anterior or posterior.

Fig. 308.—Encapsulated empyema, left chest, axillary position. Note the dense shadow (*a*) with its sharply outlined convex outer border and attachment to the lateral chest wall.

Fig. 309.—Multiple encapsulated empyema, postero-anterior view, right side, supine position. There is a large axillary encapsulation (*a*) with the characteristic sharply defined outer border. A superior mediastinal encapsulation (*b*) is in the medial portion of the pleura lying somewhat anteriorly. A second mediastinal encapsulation (*c*) is situated posteriorly behind the heart. In occasional cases numerous pockets of this type may be visualized and their exact location delineated.

Fig. 310.—Free pleural effusion from cardiac failure simulating encapsulations in the interlobar spaces, right lateral decubitus position. As shown in Figures 297 and 298 (p. 337) and Figure 302 (p. 341), free fluid may extend into the interlobar fissure and may sometimes simulate encapsulation or actually become encysted there. This is common in cardiac disease. The film shows a free effusion (*c*) and extension into the horizontal (*d*) and the oblique interlobar fissure (*e*).

Fig. 311.—Mediastinal empyema. In some cases the fluid encysts itself in the mediastinal portion of the pleural space, giving a characteristic shadow suggesting a double heart. The outer border of the mediastinal effusion (*a*) is sharply defined. The heart (*f*) is displaced to the left, as is often the case with this particular type of encapsulation.

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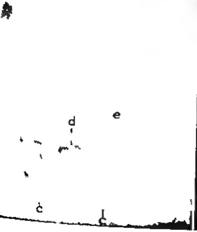

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Fig 312A —Encapsulation in the interlobar fissure pneumonia with beginning pleural effusion anteroposterior view supine position *a* pneumonic consolidation at the base of the right lung *b* increase in thickness of the horizontal fissure A slight decrease in radiability throughout the right lung indicates the presence of a small amount of free fluid

Fig 312B —Same case 48 hours later Diffuse pleural effusion (*c*) is now especially clear near the base The interlobar fissure (*b*) has become much wider than it was on the previous examination and has assumed a bandlike shape

Fig 312C —Ten days later anteroposterior view supine position The free pleural effusion had been drained but the drainage tube lies posteriorly The fluid has nearly cleared from the major pleural cavity but is becoming encysted in the horizontal interlobar fissure (*b*) Note the characteristic rather oval fusiform shape of this type of encapsulation Such deep encapsulations in the interlobar fissures are difficult to detect on physical examination

Fig 312D —Lateral view made on the same date The position of the minor horizontal interlobar fissure is well delineated by the encapsulated pocket of fluid within it (*b*) The major fissure is also thickened and can be made out both between middle and lower lobes below (*d*) and between upper and lower lobes above (*d*) The drainage tube (*c*) lies in the posterior pleural space well back of the encapsulation which had to be drained separately

[Encapsulated effusions Interlobar *continued on page 350*]

b
12A
312 C
d
b
d
312 D

Encapsulations in the interlobar fissures are usually best demonstrated in the lateral view. This is especially true of the oblique fissure.

Fig. 313.—Encapsulated fluid in the right oblique fissure. *a*, somewhat triangular shadow of the fluid. Its position corresponds well to that of the oblique fissure. *c*, right diaphragm markedly elevated; note its superimposition on the cardiac shadow (*d*).

Fig. 314.—Encapsulated empyema in the oblique fissure. *a*, oval area of density in the superior portion of the oblique fissure. *b*, thickening of the rest of the interlobar fissure. *c*, right diaphragm markedly elevated. The superimposition of the diaphragm on the cardiac shadow produces an appearance simulating that of encapsulation in the interlobar fissure. The posterior border of the heart (*d*) should always be taken into consideration.

Fig. 315A.—Mediastino-interlobar effusion, postero-anterior view, upright position. The changes around the outer borders of the heart (*a*) are seen, although rather indistinctly. To visualize fluid which extends from the mediastinum into the interlobar fissures, which communicate with the mediastinum near the heart, a film must be made in the position of lordosis.

Fig. 315B.—Same case, position of lordosis. *a*, triangular shadows indicating fluid extending into the mediastinum from the interlobar fissures. *b*, lateral extension of the thickened interlobar fissure. It should be borne in mind that in the position of lordosis atelectasis and carnification of the right middle lobe sometimes produce a similar triangular shadow.


a
c
3
a
b
c
d
314
b
a
b
315B

Fig 316—Minimal pneumothorax spontaneous nontuberculous right side only *a*, area of pneumothorax near the apex of the lung Note the absence of any lung pattern in this area denoting the presence of air outside the lung *b* edge of collapsed lung separated from the parietal pleura This faint white line represents a combination of the visceral pleura and the compressed underlying lung Such small areas of pneumothorax are easily overlooked and are best demonstrated by films made in deep expiration *c* pleural reaction with a small amount of fluid obliterating the costophrenic sinus

Fig 317—Moderate pneumothorax, spontaneous with considerable collapse right side only *a*, air in the pleural cavity with absence of linear markings and increased radiability *b*, edge of collapsed lung *c* interlobar fissure which is adherent preventing separation of the lobes The separation of the lower lobe (*d*) and of an inferior accessory lobe (*e*) can be made out, although somewhat faintly The radiability of the partially collapsed lung has not decreased appreciably This is in contrast to the marked density of the lung in obstructive atelectasis

Fig 318—Traumatic pneumothorax fractured ribs Marked collapse of the lung and extension of the air into the soft tissues have occurred *a* air in the pleural cavity *f* intrapulmonary hemorrhage producing an area of increased density in the lung *g* gas extending from the posterior mediastinal space into the posterior cervical fascia causing subcutaneous emphysema *h* subcutaneous emphysema in the axillary area *i* stripelike shadows representing emphysema probably within the muscle fibers of the anterior chest wall *j* multiple fractures of the ribs

Fig 319—Artificial pneumothorax tuberculosis with adhesions upright position *a* air in the pleural cavity *b* edge of collapsed lower lobe *c* typical pleural adhesion holding the upper lobe from complete collapse and extending well out to the peripheral pleura *k* edge of rib sharply outlined in contrast with the pneumothorax *l* fluid in the pleural cavity in the upright position the fluid level is flat *m* tuberculous cavity with infiltration in the right lung

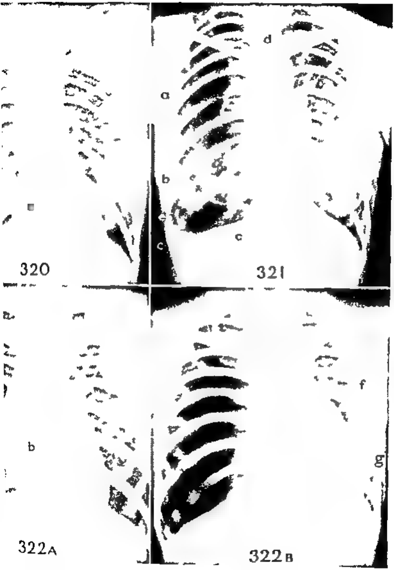

316
318
319
7
g
m
b
c
a
b
k

Fig 320—Pneumothorax artificial with adhesions and fibrin body *a* air in the pleural cavity *b* edge of collapsed lung showing shadow of visceral pleura and compressed lung beneath it Some adhesions in the apex prevent complete collapse *c*, shadow of a large fibrin body caused by bleeding during the induction of pneumothorax Part is superimposed on the lung and part extends beyond into the pleural cavity Such accumulations are common in pneumothorax and must not be mistaken for tumors

Fig 321 — Artificial pneumothorax tuberculosis with adhesions *a* air in the pleural cavity *b* edge of collapsed lung *c* fibrin body superimposed on the shadow of the diaphragm and therefore seen with some difficulty *d* bandlike pleural adhesion preventing collapse of apex *e* margin of breast shadow

Fig 322A—Pneumothorax effect of respiration on demonstration of mediastinal hernia postero anterior view in deep inspiration *a* pneumothorax *b* margin of collapsed lung *d* diaphragmatic attachments

Fig 322B—Same case film made in deep expiration Note the increased displacement of the heart to the left indicated by the position of the left border (*g*) and absence of any cardiac or lung shadows to the right of the spine The mediastinal hernia (*f*) can be made out with the pneumothorax on the right herniating into the left hemithorax This phenomenon occurs with pneumothorax when the mediastinum is not fixed if the pressure on one side becomes too severe It is important to bear in mind that mediastinal hernia and minimal pneumothorax can often be demonstrated only by films made in the expiratory phase



320 321

322A 322B

Fig 323A—Artificial pneumothorax in tuberculosis antero-posterior view supine position *a* air in the pleural cavity *b* thickened visceral pleura and edge of lung *c*, adhesions of the lung to the parietal pleura The thickened parietal pleura (*d*) is clearly visible because of contrast with the pneumothorax *e* cavity in the lung It should be noted that there is also marked thickening of the pleura (*d*) on the left side

Fig 323B—Same case upright position Hydropneumothorax can be demonstrated effectively only in the upright or one of the decubitus positions so that the interface between fluid and gas is demonstrated *a* pneumothorax *f* fluid level of an encapsulated hydropneumothorax Note that no sign of the fluid level could be made out in the film made in the supine position *g* artefact

Fig 324A—Hydropneumothorax with adhesions following artificial pneumothorax postero anterior view upright position *a* pneumothorax *b* edge of lung and visceral pleura *c* adhesions at the apex *f* fluid level well shown in the upright position *h* fibrin body

Fig 324B—Same case left lateral decubitus position Note the change in the fluid level which corresponds well to the change in the patient's position As a result of the pneumothorax gravity is the sole factor *a* pneumothorax *b* edge of collapsed lung *f* fluid level *h* fibrin body A layer of fluid on the left side (*h*) exhibited in this film is not seen at all in the film made in the upright position The value of the lateral decubitus position for revealing small amounts of fluid in the pleural cavity is again demonstrated

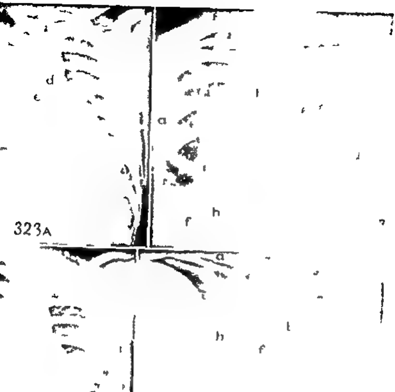

d
a
h
f
323A
a
h
f
323B
324B

Fig 325A —Encapsulated pyopneumothorax, lateral view upright position a anterior margin of encapsulated pocket *b* fluid level within the pocket The encysted fluid and gas occupy a posterior position because of attachment to the posterior chest wall

Fig 325B —Same case left lateral decubitus position The fluid level (*b*) has changed completely now having a horizontal level corresponding to the changed position of the patient The mediolateral diameter of the pocket is much better shown here whereas in the lateral view the anteroposterior diameter is best shown

Fig 326A —Tension pneumothorax from an old partially encapsulated empyema *a*, sharply outlined outer border of the pneumothorax The air pocket does not occupy the entire hemithorax from anterior to posterior surfaces therefore bronchovascular markings can be made out within the shadow of the pneumothorax

Fig 326B —Same case five weeks later There is a striking increase in the size of the pneumothorax pocket which continued to expand despite therapeutic measures Note the lower margin (*a*) almost at the diaphragm The bronchopleural fistula present had a valvelike action which caused tension within the cavity and eventually caused the patient's death The distinction between such a lesion and an air cyst of the lung is rather difficult In this case the presence of empyema before development of the pneumothorax helped to make the distinction more definite Diagnosis was confirmed at autopsy


a
325 A
c
326 A
b
a
326 B

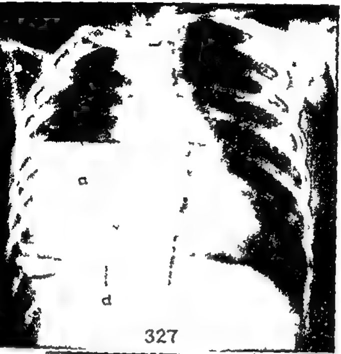
OPAQUE MEDIUMS IN THE PLEURAL CAVITY

By the injection of iodized oil or other contrast mediums heavier than air the limitations of a pocket in the pleural cavity can be demonstrated more clearly than by the simple roentgenogram. Also by this means *bronchopleural fistulas can be observed*. It *is important to use a harmless nonirritating substance* because the presence of a bronchial fistula can never be excluded and if an irritating substance should enter the bronchus a severe spasm may eventuate possibly with dire results.

Fig 327.—Pyopneumothorax upright position after injection of *iodized oil through the chest wall a fluid level between the purulent material and the gas in the pocket above b conspicuously thickened edematous parietal pleura c iodized oil remaining at the bottom and giving a clear indication of the exact inferior position of the pocket and a guide to surgical procedures d* marker placed on the skin to facilitate localization.

Fig 328.—*Bronchial fistulas demonstrated by injection of oil through a bronchopleurocutaneous sinus. The draining sinus had* been present a long time. *Iodized oil was injected through the* drainage opening (*c*). The parietal pleura (*b*) is markedly thickened. Extension of the oil into the cavity of the pleura (*f*) can be seen. The bronchial fistula (*g*) and extension of iodized oil into the bronchus (*h*) are well demonstrated. There are some adhesions *in the empyema cavity* as shown by the various pockets (*f*).

Fig 329.—Bronchopleural fistulas *demonstrated by injection* of iodized oil *c* drainage tube in the *empyema cavity f* the cavity filled with iodized oil *g* one of the numerous bronchial fistulas which can be made out *h* right main bronchus into which oil entered through a fistula.



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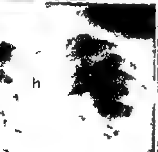

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PLEURAL TUMORS The major primary tumors of the pleura are mesotheliomas and endotheliomas malignant tumors which tend to involve the lung and erode the ribs

Fig 330A—Mesothelioma of pleura postero anterior view This tumor was discovered during routine examination before there were any symptoms Note the rather sharply defined nodular shadow (*a*) with convex outer border It resembles an old encapsulated pocket in the pleura except for its somewhat lobulated character It also resembles a tuberculoma Rapid onset of symptoms after discovery of the shadow led to further study which revealed that it was an endothelioma It was removed surgically

Fig 330B—Same case 17 months later A massive recurrence on the left side (*c*) involves the pericardium and mediastinal pleura of the left lung The defect in the right thoracic wall (*b*) shows where the original tumor was removed The patient died of the recurrence

Fig 331—Endothelioma of the pleura with erosion of the ribs and pneumothorax *a* tumor of the parietal pleura exhibiting itself as a dense shadow extending into the thoracic cavity and seen in sharp contrast with the pneumothorax (*c*) *b* remains of the eroded sixth rib the posterior portion of which has almost completely disappeared leaving only this small residuum *d* edge of the collapsed lung The pneumothorax was induced to facilitate the diagnosis

Fig 332—Multiple endothelioma of the pleura with hydropneumothorax *a* various nodular tumors and thickened pleura due to the tumor *c* pneumothorax artificially induced *d* tumor of the visceral pleura *e* border of collapsed lung *f* fluid in the pleural cavity Fluid often appears early accumulates rapidly and unless removed will obscure the shadows of the tumor


c
a
b
330A
330B
a
a
a
d
d
e
c
f
331
332

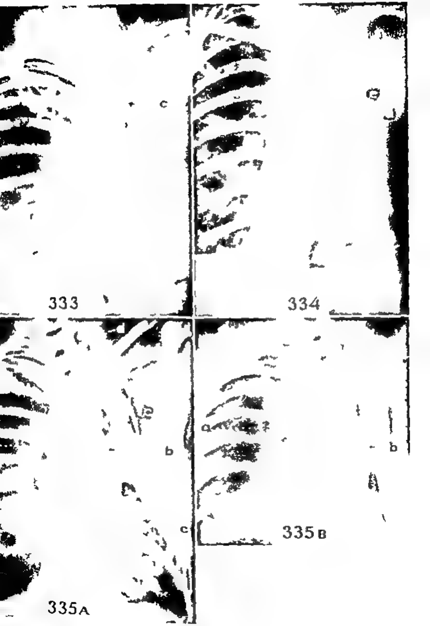
POSTOPERATIVE THORACIC CHANGES After operation on the thoracic wall particularly thoracoplasty, definite changes in the roentgen appearance are observed

Fig 333—*Thoracoplasty with fairly* good collapse of the lung *Deformities of the ribs and their regeneration* are well made out Scoliosis of the spine occurs secondarily Some aerated lung with a small area of increased radiability (c) represents a residual cavity The finding is suggestive but not diagnostic of cavity Further studies using the Potter Bucky diaphragm and body section roentgenography would be helpful

Fig 334—Thoracoplasty with only partial collapse and sec ondary *bronchiectasis Regeneration of the ribs* (*d*) *which are extremely irregular can be seen Iodized oil* introduced through the trachea is seen in the dilated bronchi (*e*) Such bronchial changes are common after thoracoplasty

Fig 335A—Thoracoplasty for tuberculosis with residual cavitation postero anterior view overexposed *a* rounded shadows in the right lung suggestive of cavitation *b* residual cavity in the left lung despite thoracoplasty *c* lung which is still expanded *d* regenerating rib

Fig 335B—*Same case* body section roentgenogram The cavities (*a* and *b*) on both sides are clearly delineated *In such circumstances* body section roentgenography is of the first importance


c
333
334
a
b
b
c
335A
335B

POSTOPERATIVE LUNG CHANGES Lobectomy and pneumonectomy are now being undertaken frequently The roentgen appearance of the lungs after such surgical procedures is variable

Fig 336A—Right lower lobectomy for bronchiectasis 12 months after operation postero anterior view The right diaphragm is elevated In the base of the lung are some irregular areas of increased density with cavities within them (*a*) Aside from this the lungs appear normal

Fig 336B—Same case bronchogram left oblique view The dilated bronchi (*b*) of the middle lobe representing residual bronchiectasis lie posteriorly where they replace the absent lower lobe The lower branches of the upper lobe bronchus are also dilated and come down to the diaphragm (*c*) which is elevated *d* posterior border of the heart

Fig 337—Pneumonectomy for carcinoma (same case as Fig 231 p 295) bedside film supine position shortly after surgery The right lung is absent and the hemithorax is filled with air although some fluid is accumulating at the base (*e*) The tumor had invaded the thoracic wall (*f*) and so could not be completely removed There is some subcutaneous emphysema in the cervical region (*g*) In time the cavity fills with fluid the mediastinum is retracted and the ribs collapse to fill the empty space

Fig 338—Pneumonectomy for lung cyst in a child aged 15 (same case as Fig 183 p 183) This roentgenogram was made 11 months after extirpation of entire right lung because of an expanding lung cyst It shows the typical appearance of the chest some time after pneumonectomy *d* left border of the heart at the midline indicating marked displacement *h* trachea displaced sharply to the right The entire right hemithorax is dense from fluid and the shadow of the heart *i* resected rib regenerated *j* overlapping arm producing a confusing shadow

336A

336B

337

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